VOICE RECOGNITION AS AN INPUT MODALITY FOR THE TACCO PREFLIGHT DATA INSERTION TASK IN THE P-3C AIRCRAFT

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THESIS

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for the Tacco Preflight Data Insertion Task
in the P-3C Aircraft

by

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I. INTRODUCTION

Airborne ANTI-SUBMARINE WARFARE (ASW) systems process a large amount of data resulting in a considerable workload for system operators. Modern systems require an operator to interface closely with digital machines primarily through some type of keyboard entry device. This channel of communication can become overloaded when the workload is high in the tactical environment, or when large amounts of data need to be laboriously entered through the keyboard such as occurs during preflight data entry of search stores, weapons inventory and navigation preflight data in the P-3C weapon system.

A. THE P-3 MISSION

The P-3C is a four engine, low wing aircraft designed for patrol and antisubmarine warfare. It carries a crew of eleven officers and enlisted technicians consisting of a Pilot/Co-pilot/3rd-pilot, Tactical Coordinator (TACCO), Navigator Communicator (NAVCOM), Flight engineer, Sensor Station 1,2, and 3 (SS1,SS2,SS3), Inflight technician and an Ordnanceman.

The mission of the P-3C is varied and includes Search and Rescue, Photo/Recon, and Mining in addition to it's primary task of ASW. The ASW task of the P-3C is

detection, localization, surveillance, and attack of targets that pose potential military threat. Satisfactory pursuit of this mission requires that each crewmember possess a thorough knowledge of the equipment at his station and it's computer interface.

The AN/ASQ-114 digital computer on the P-3C is the heart of data management of the weapon system. It is a miniaturized general purpose digital computer used for data processing and display. It accepts data from crew operators and various aircraft equipment. It then processes these inputs to:

1. Control, synchronize, and maintain symbology on tactical and auxiliary displays.

2. Provide for recording of flight data for use in in-flight recovery operations and post-flight analysis of the mission.

3. Manage and control the aircraft navigation systems.

4. Manage search store and weapon inventories.

5. Control search store and weapon releases.

6. Communicate with other stations via data link and teletype.

7. Monitor and control sonobuoy receiver assignments.

8. Manage and control the electronic support measures system.

9. Perform preflight and maintenance testing of associated equipment.

Most of the data that is processed by the ASQ-114 is based on instructions that are contained in the operational program which is loaded into memory from a magnetic tape.

Additionally, data which is mission specific is loaded onto the end of the operational program tape into a preflight data insertion program or PDIP by personnel from the ASWOC. One of the areas of difficulty in completing the PDIP is the insertion of search stores into the "Stores Management" tableau. Search stores are comprised of sonobuoys, smoke markers, and bathythermographs. Changing requirements and availability of particular sonobuoys for a specific mission often precludes the insertion of these sonobouys into the PDIP. The Tacco must then enter the sonobouys into the "Stores Management" tableau after preflighting the aircraft and subsequent to loading of the operational program. The process is time consuming and errors frequently occur due to distractions from other crewmembers and because of the redundant nature of the task.

Previous studies, by Lea [Ref. 1] and Fuede and Greer [Ref. 2] have looked at the work load of crew members and have explored the possible use of automated speech technology to increase operator performance during various portions of the P-3C mission. This study will evaluate the use of the Model T600 Threshold Technology, Inc. voice recognition unit during pre-flight data entry tasks performed by the Tactical Coordinator in the P-3C aircraft. Results of the voice data entry method will be compared with those using standard keyboard entry method considering the metrics of 1) entry speed, and 2) accuracy.

B. GENERAL CONSIDERATIONS IN MAN-COMPUTER INTERACTION

Man has one channel - speech - with which he does most of his communicating with other people, and three channels - manual, visual and audio - with which he does most of his communicating with his machines. In general, manual means are used in man-computer communication and visual means are used in computer-man communications. Keyboards, of course, are the primary input device in most applications, However, that doesn't mean that they are, necessarily, the best type for most applications. The following questions should be answered before that judgment is made:

1. Is the input alphanumerics, strictly digits or words, or sentences etc.?

2. Is the input strictly formatted?

3. Is there considerable mental or visual effort required to manipulate the data before it can be entered?

4. To what extent will the input be interactive with the computer?

5. What will be the mobility requirements for the operator.

6. Is it desirable for the operator to be able to perform secondary tasks along with the data entry task?

7. Will the operator be under unusual environmental stress?

8. Who will the operators be?

9. How much experience will the operators have with the data input device?

10. How important is input error rate to the application?

11. How important is entry speed to the application?

12. Will the operator be required to interface with other operators while he is using the input device?

C. SPEECH RECOGNITION - AN OVERVIEW

All human languages consist of groups of sounds called phonemes which are created by the interaction of various speech articulators: lips, tongue, teeth and palate. There are five, generally accepted categories of articulation [Ref. 3 and 4]:

1. PLOSIVES or STOPS which act to stop the passage of air, such as 't' in "top".

2. FRICATIVES which are caused by forming a narrow slit for air passage; such as 'th' in the word 'their'.

3. LATERALS which are formed by closing the middle line of the mouth; such as 'l' in the word 'laugh'.

4. TRILLS which are formed by the rapid vibration of an articulator such as the trilled 'r' in some languages.

5. VOWELS which are formed by unobstructed air flow over the vocal chords.

In English, there are about 16 different vowel sounds and 22 different consonant variations, providing about 38 different phonemes. Besides the actual sound generated by the different categories of phonemes, the intensity or power generated varies significantly from case to case. Vowels allow much more power transmission than consonants, with the greatest difference being about 28 dB - a factor of approximately 680 [Ref. 3].

Speech 'quality' is a rather elusive term, but can be thought of as a measure of two qualities: pitch (frequency)

and loudness (power). Intelligibility is an even more elusive parameter. It varies with quality, context, vocabulary size and background noise level. Generally, intelligibility is enhanced when the size of the users vocabulary is reduced, as is the case with air traffic controller-to-aircraft communications [Ref. 5]. Both the pilot of the aircraft and the controller use standard phraseology from a defined vocabulary for the bulk of their transmissions. Also, intelligibility is enhanced in this situation by the expectation on the part of both participants - the controller and the pilot - as to what the other will say, in effect, further reducing the size of the vocabulary. Aircraft communications also make use of another aspect of intelligibility: that of improving the power of the spoken sounds by using the phonetic alphabet instead of standard letter pronunciations or the use of the word 'roger' instead of 'OK'.

Since human speech often is processed by electronic systems, another factor to consider is that of frequency filtering. Some phonemes, such as the 'ssss' sound are sharply affected by filtering of frequencies above 4 KHz, while most short vowels are affected by filtering frequencies below 1 KHz. Although frequency components of human speech vary between men and women, from person to person, and even from day to day for a single person, most are contained within the range of 400 Hz to 4000 Hz. The

bulk is between 1 KHZ and 3 KHZ [Ref. 5]. Generally, filtering will not make speech unintelligible. However, it will make it seem 'unnatural'.

The very nature of speech, with its rich endowment of sounds, inflections, moods and variety, makes it an extremely difficult modality to quantify. Lea [Ref. 5] puts it this way:

> "No two utterances are exactly alike, and the communicative ability of speech is due to resemblance between successive utterances."

Thus, it would seem that the real challenge of human speech processing by machine is to determine what features carry the information in speech and then use them to process the utterance and decipher its 'meaning'.

Conceptually, there are a number of approaches to the development of a human speech processing machine [Ref. 5]:

1. ACOUSTICAL SIGNAL APPROACH: treats the problem as purely one of determining the frequency spectrum of the speech input. This process has been enhanced by the development of the Fast Fourier Transform (FFT) algorithm which allows a considerable time saving in doing the spectral analysis.

2. SPEECH PRODUCTION APPROACH: considers the method of speech production in humans and attempts to decipher the speech by considering the effects of vocal tract resonances, vibration of the vocal cords, and methods of articulation.

3. SENSORY RECEPTION APPROACH: suggests that speech could be deciphered by duplicating the processes that occur in the ear and the interpretive components of the brain.

4. SPEECH PERCEPTION APPROACH: attempts to extract features and make categorical distinctions that are experimentally established as being important to human

perception of speech. All so-called vowel distinguishers fall into this category.

Speech processing systems are naturally divided into two distinct categories: continuous speech systems and isolated speech systems. Isolated speech systems generally deal with distinct utterances, typically of up to two seconds in length [Ref. 6]. Also, most current systems require a 100 ms pause between utterances [Ref. 5]. Note the use of the term utterance vice word, as the utterance may consist of a single word or a phrase. Isolated speech processors have found their way into industry in great numbers. They allow a mail service employee to have his hands free to properly orient packages so that he may announce their destinations to the voice recognizer. They permit paraplegics to use use voice-controlled wheelchairs. They are used on production lines and permit user mobility in performing quality assurance tasks. Most current isolated speech processors utilize a form of spectral analysis to 'recognize' the input.

Continuous speech processing systems have an inherently more difficult analysis to perform. They must actually interpret the spoken language. This is a monumental undertaking. Even if we do not consider the problem of interpreting homonyms - words which have exactly the same sound - there remains the problem of defining word boundaries within the context of sentences. The boundary

sounds of a word are highly dependent on what words occur immediately before and after it as it is spoken. Also contractions occur frequently, further modifying the word sound. Thus, the phrase "would you get..." might sound more like "wouja get..." when actually spoken.

The logical follow-on to a system which could recognize continuous speech would be one which actually would be able to understand it. This is another quantum leap in complexity. When humans communicate with speech, they use a complex, learned behavior which considers many aspects of the incoming pattern of speech. A human considers the context of the utterance, the task being performed and his understanding of English syntax to form an expectation of what the words will be and what they should mean. Then he performs semantic analysis on his perception of what the utterance was to determine if it makes sense [Ref. 4]. If not, the process is repeated. This iterative process is continued until the input makes sense.

Continuous speech recognition systems do currently exist, and they do work. However present technology has not been able to provide the execution speed necessary to allow these machines to operate at anything approaching real time. They may take many minutes to process 30 seconds of speech.

It is certainly valid to ask why it is that, given the difficulties involved, we continue to pursue the use of speech as an input modality. The answer has many facets,

some of which are more obvious than others [Ref. 7]. First, it is speech which man uses in his daily communications with others. Thus it is both convenient and natural. If artificial syntax or unnaturally restrictive vocabularies can be avoided, the speech input language requires very little learning or adaptation as would be necessary with special keyboard codes. Speech is a very high capacity input modality. Table 1 shows that the data rate achieved when speaking non-technical prose is nearly twice that achievable by the skilled typist. Using speech, it is possible to communicate with other people and the computer simultaneously. This may have advantages in certain time-critical applications.

A major advantage of using speech input is that it allows the user unusual mobility. Since the input device is a microphone, generally worn as an attachment to a head band, there is complete freedom within the area allowed by the length of the microphone cord to move about a work area. There is actually freedom to move in any of the three axis, to any arbitrary orientation. At the same time, the system also allows supplementary tasks to be performed as the voice input is being made. Certain inputs to critical operations may require verification before continuing on to a subsequent step. Generally, this would require two successive keyboard inputs. This process could be performed

more quickly if voice input was used as a verification or primary command input device.

One quite interesting aspect of speech communication is that each person's voice qualities and mannerisms are quite unique, and may be used to verify the speaker's identity. The qualities of the voice also change for a single person from day to day, in response to stress, emotional condition, colds and other factors, which may complicate the problem. However, given a sophisticated enough processor, these changes could be used by a machine to tell its user that he has been under too much stress and that he should see a doctor and stop working so hard!

Of course, speech input is not a panacea and it has its disadvantages. The constraints of artificial syntax and highly restrictive vocabularies may outweigh any claims to its being natural, thus requiring considerable learning. Background noise can adversely affect the recognition accuracy of the machine. The individual differences in voice characteristics which makes it possible to verify a person's identity, also generally makes voice input systems one person machines. This is generally manifested by the requirement for a training session, during which a prospective user will speak each word of the vocabulary up to 10 times. The results are loaded onto a cassette tape, which must then be read by the machine prior to its use by any new user.

D. PREVIOUS WORK WITH VOICE INPUT

A technical report published in September 1977 by Threshold Technology Inc. for the Rome Air Development Center, [Ref. 8] describes work which compared the effectiveness of three different input devices under various conditions. The three input devices tested were a common computer terminal, a Graf pen, and the VIP 100 voice recognition system built by Threshold Technology Inc. The Graf pen is a somewhat unusual device, which is used in the same manner as the more modern digitizer tablet or CRT light pen. It allows the user to input a word by touching the device to the place where the word appears on a 'menu'. The Graft pen differs from the more modern devices in that it generates a spark when pressed against the menu the sound of which is received by sensors located around the peripnery of the menu area. The sensors allow the system to thus fix the position of the pen when it was pressed against the menu, thus, locating the desired input string.

There were two categories of tests used in the comparison: a high speed data entry task and a high complexity data entry task. The high speed data entry task required subjects to enter strings of characters as they were presented on a Burroughs 16 character Self Scan display. Numerous factors were used as variables during this experiment, among them:

1. Length of strings

2. Hand occupation

3. The type of characters, ie. alphanumeric or strictly numeric.

The hand occupation task, when used, consisted of the requirement to simultaneously depress two pushbuttons separated by 14 inches before the required input strings would be displayed on the Burroughs unit.

The results were categorized by factors affecting entry speed, input error rate, and operational error rate - a measure of errors remaining after the operator corrected all of his observed errors. In this test, the keyboard was the fastest device - requiring 29 percent less time per character than voice which finished last in speed. This was primarily a result of the much higher input error rate demonstrated by the voice unit - twice that of either of the other modes. Alphanumeric data required 23 percent more time than numeric entry for all of the devices and was judged the most significant variable affecting data entry speed. There was no significant difference in the operational error rate among the various entry devices. The most significant factor affecting the errors remaining after correction was the type of characters used. Alphanumeric strings had nearly twice the error rate as pure numeric strings. This was partially attributed to reading or interpretation errors such as mistaking a zero for the letter 'o' or the number one for the letter 'l'.

The second general category of tests comprised what was called the high complexity data entry task. This task simulated an air traffic control flight plan amendments and corrections scenario. The desired amendment was given to the subjects in text form and they were required to enter the change into the system. The subjects were first required to enter the category of the amendment (CANCEL a flight, amend routing, HANDOFF a flight, etc) after which the system would present prompts to obtain the data required to carry out the request. The text of the desired change contained all of the information required to make the change. However, in the text version, the data items were not presented in the same sequence in which the system prompts requested the data. Thus the subjects were required to interpret the text version to determine the proper responses to the system prompts.

The significant variables included hand occupation, subject experience with the entry device and number of trials already completed. Again, factors affecting the three categories of entry speed, operational error rate, and input error rate were examined. The choice of entry device was a significant factor in entry speed, with the voice system and Graf pen not significantly different, but both about 30 percent faster than the keyboard,even though the keyboard users were permitted to use two-letter abbreviations for the commands.

Experience level, however, provided an even greater variance in entry speed. The increase in entry time per word for inexperienced keyboard users, using the keyboard as the entry device was 56 percent. The increase for inexperienced Graf pen users using the Graf pen as the entry device was 14 percent, and for inexperienced voice recognition system users, only 5 percent! Thus, it would appear that inexperienced users of voice input achieve their maximum data input speed with much less practice than inexperienced users of keyboard input. Note that this is indicated for entry speed only. The question of entry accuracy will be addressed subsequently. The hand occupation task required depressing both of the pushbuttons previously mentioned for 3.5 seconds for each input message. As might be expected, this task affected the Graf pen users (30 percent slower) and the keyboard users (20 percent slower) to a much greater extent than the voice users(9 percent slower).

Again, there were no significant differences between the three entry devices in operational error rate. Significantly, though, the bulk of the voice system errors were recognition errors(ie high basic error rate) while the majority of the errors with the other two systems were reading or interpretation errors. As a group, the inexperienced users of all three input devices suffered a 50 percent increase in total word errors after correction. There was no significant indications of differences in this

observation among the three input modes. Thus, it appears that although entry speed suffers less from inexperience with voice input as the entry mode, the error rate is about 50 percent higher regardless of entry mode. The combination of lack of experience and hand occupation did significantly increase the operational error rate, primarily because this tended to increase the number of reading errors. The basic error rate of the voice input system was four times higher than that of the other two modes. This was due to its poor recognition performance and confusing error correction system. The correction system allowed a backspace over a previous character or an erase of the entire input line. There was some confusion over the meaning of the correction words, so that the ERASE command was occasionally used when a backspace was desired, thereby requiring the entire line to be reentered. Additionally, the poor recognition performance led to numerous incorrect matches with these correction words, causing additional confusion.

An FAA report released in August 1979, [Ref. 4], describes work done by its experimental center on the use of a voice input system in a simulated air traffic control environment. There were actually two experiments conducted. The first examined just the recognition accuracy of the VTR 100 voice recognition unit manufactured by Threshold Technology, Inc., using a vocabulary of standard terms descriptive of the data entry language already in use with

keyset systems. The second experiment compared the speed and accuracy of the voice input system with that of a keyset system currently in use within the air traffic control system.

In the first experiment, an operational vocabulary was divided into three sub-vocabularies: Message types(15 words), Geographical Fixes(21 words) and Digits and Control Words(12 words). Data for each of these subvocabularies was maintained separately. The subvocabularies were then each expanded into a list consisting of ten repetitions of the member words randomly positioned so that the Message list contained 150 words, the Fixes list 210 words, and the Digits and Control words 120. Each subject was required to read these lists during multiple testing sessions - ten sessions for the Message and Fix subvocabularies and five sessions for the Control words subvocabulary.

The results of these tests demonstrated some interesting characteristics of the voice input process. Considering an error to be either a failure to recognize an input(ie. no output string) or an incorrect match, the Message subvocabulary had the highest error rate with 3.2 percent, the Fixes subvocabulary had the next highest with 2.2 and the Digits and Control words had the lowest with 1.0 percent. The Message subvocabulary also was the first vocabulary tested, followed by the Fixes vocabulary and, finally, the Control words vocabulary. Thus, the subjects

tended to decrease their error rate as they gained experience with the system. The drop from 3.2 percent to 1.9 percent represents a 41 percent decrease in error rate, a figure which agrees closely with the results of reference [Ref. 8] presented previously.

It is also important to note the variability in the error rate within each subvocabulary. There are words in each which show error rates from one fourth of the average to four times or more of the average rate. Not shown on the tables is the fact that the performance of individual speakers shows similar variability. The individual speaker error rates varied from zero to nearly 7 percent. From one-half to two-thirds of the errors reported for the most error-prone words were accounted for by one or two of the speakers.

The second experiment was designed to compare the performance of the voice input system to a currently used keyset device in scenarios which simulate an actual ATC nonradar control position task somewhat similar to that used in the MCDE experiment described in reference [Ref. 9]. Two sets of 100 realistic messages were constructed using the three subvocabularies tested in the first experiment. These two groups of 100 messages were further divided into four groups of 25 messages which were used as a single run with short rest periods between groups. The proportions of the various categories of messages was carefully controlled to

simulate the approximate mix which a controller would actually see while actually performing the nonradar controllers position job in an Enroute Center. The order of the messages was random, and text of the messages did not present data in the same order as the system required it to be entered. Thus it was necessary for each of the operators to translate the desired entry into the syntax which his entry device required and order the data so that the host system would accept it.

Five operators participated in this test, only one of whom had participated in the first experiment. Thus, four of the five had no experience with voice entry devices and required basic training in the proper use of that system. It should also be noted that the keyset entry device did employ so called 'quick action' buttons for the most common message types. This allowed the entry of the more frequently encountered message types with a single key stroke. All other message types were entered using a two character abbreviation.

Data was collected on both data entry speed and error rates for each of the five participants. Total errors were divided into three groups, according to their cause:

1. LANGUAGE errors caused by using an incorrect command, such as "drop track" on the voice system or "FO" on the keyset instead of "cancel" or "CX" respectively.

2. FORMAT errors caused by not using proper delimiters or spaces between the parts of an input message.

3. CHARACTER errors caused by recognition errors with the voice input or keystroke errors with the keyset.

Voice input demonstrated a significantly lower overall operational error rate. That is, errors remaining after the operator had finished the trial. The overall rate for voice input was less than half of that for the keyset. Significantly, the voice input demonstrated its forte for easily handling strictly formatted output by a formatting error rate of zero. The character error rate was 25 percent less, and the language error rate was 66 percent less using voice input. The fact that language errors are three times more frequent using the keyset than they are using the voice system supports the concept of a 'natural language' advantage for voice input. Corroborating data was gathered on the 'translation time' for each message - defined as the time period between receipt of the desired message by the operator and his first data entry. This roughly corresponds to the time required to translate the text request into a syntactically correct system message. Throughout the testing there remained a distinct advantage for the voice input in this area. Initially, the translation process took 50 percent longer with the keyset. This advantage continued to accumulate until near the end of testing, as the users of the voice system became more adept at using it, translation time was 100 percent longer with the keyset. Again, there was considerable variance in error

rates among the five operators, with voice input showing the most extreme effects. The 'worst' ones produced an order of magnitude more errors than the 'best' ones.

The results for the data entry rates showed no clear advantage to either input device when all of the input messages were considered, although the fastest rate was recorded by one operator while using voice input, and the slowest rate was recorded by one operator using the keyset. However, when the analysis considered only the types of messages which required short commands and mostly digit entry, there was a 20 to 30 percent advantage in entry speed for the keyset.

The results of these two reports served as the basis for the current work. The conclusions have provided the incentive to pursue a practical application of voice input technology to current Fleet problems. A brief summary of these conclusions appears below:

1. Voice input technology has been demonstrated to have a definite advantage in data entry rate and/or accuracy over keyboard devices for applications requiring substantial mental or visual effort, or those requiring tedious, strictly formatted input.

2. Very high recognition accuracy is possible with commercially available units.

3. A users lack of experience affects the data entry speed of voice input much less than it does keyboard input. This suggests that 'trainees' might achieve their maximum input speed with voice input much sooner than they would with keyboard input.

4. Discrete word voice recognition units are not well suited for data entry tasks requiring entries of large

numbers of single characters, groups of which cannot be output by the voice input unit with a single utterance.

5. Current voice input units are sensitive to operator characteristics and may require retraining of the vocabulary if these characteristics change appreciably.

6. A data entry device should have a simple, logical and easily understood correction system.

II. SETUP

A. VOICE INPUT HARDWARE

The Threshold 600 is a discrete speech recognition unit manufactured by Threshold Technology Inc, Delran, New Jersey. It has a vocabulary capacity of 256 utterances, each of which can be from 0.1 to two seconds in length. A minimum 100 ms pause is required between utterances in order for the machine to define speech boundaries. An operator may speak as rapidly as he desires, as there is no requirement for him to wait between utterances for the machine to complete processing on the previous one. However, the 100 ms pause must occur between each of the utterances. Processing time is dependent on the size of the vocabulary [Ref. 9]. However, typical times are practically instantaneous averaging 250 ms as reported by Poock [Ref. 10]. The range is approximately 100 ms to 500 ms. Processing time may be reduced by restricting the vocabulary search to any of up to 16 different sets of subvocabularies. The words in each may be exclusive or shared among any or all of subvocabularies.

The system consists of an analog speech processor, an LSI 11 microcomputer with a digital input-output interface, a display screen and keyboard, a microphone/preamp, and a cartridge tape drive. The speech processor and microcomputer are packaged in a single unit about the size

of a small suitcase, which may be remotely located up to 2000 feet from the remaining components. Electronically, the system 'looks' like any of the standard RS-232C or 20 ma current loop input device and its input will appear to a host computer like that from a common keyboard terminal. Thus, there is no special processing required of the output before it can be used by the host system.

The speech processor uses an undisclosed algorithm to extract the significant components of the speech input. It then converts these 'highlights' into digital signals which can be processed by the microcomputer. The microcomputer uses another undisclosed algorithm to compare the digitized input with what has been stored in its volatile semiconductor memory. If the necessary number or quality of characteristics agree with any of those stored for the vocabulary, a match is declared, and the predetermined output string of up to 16 characters is transmitted to the host system. If no match is made, an audible tone is produced to so indicate.

Before the system is used, however, the operational vocabulary must be 'trained'. Training consists of speaking each of the utterances in the vocabulary 10 times in succession leaving the minimum 100 ms pause between each. The system must also be given the character strings which are to be output when a member of the vocabulary is recognized. These output strings are determined by the

operator prior to the system's use and entered once using the the terminal keyboard. When this has been completed, the contents of the minicomputer core memory where this information is stored is read onto a cassette tape using the tape drive unit. This must be done for the first user after a new vocabulary has been established. Subsequent users need only read this master tape into the machine and perform the training, after which their vocabulary is read onto their tape for subsequent use.

The Threshold 600 has two operational modes: buffered and unbuffered. In the unbuffered mode, if the system finds a match for the spoken utterance, the respective output string is sent immediately to the host. If the match was not correct, then, of course, an incorrect output string is sent, without giving the operator an opportunity to intervene. This is comparable to a standard typewriter which puts a character on the paper as soon as a key is struck. At this point, any error correction is a function of the host system. If no such errors can be tolerated, or if error correction on the host system is particularly difficult, the buffered mode may be used. In this mode, the T-600 acts like a standard terminal which allows you to check your input and make any necessary corrections before you send the input to the host with a 'CARRIAGE RETURN' or 'ENTER'. The T-600 permits up to 128 inputs to be stored in the buffer, then sent in a block mode with a single transmit

command. Two correction routines are available in the buffered mode. One allows the previous output strings (which are still in the buffer) to be sequentially deleted. The second deletes the entire contents of the buffer.

B. THE SIMULATION

This section describes the simulation used in evaluating voice and keyset input for the TACCO preflight data entry task in the P-3C aircraft, beginning with some general considerations, progressing to the hardware used, and finishing with a description of the simulation program itself.

1. The Purpose of the Simulation

The purpose of the simulation program is to provide a means by which the performance of a voice input device could be evaluated using an operational vocabulary to perform an actual operational data input function. The function chosen was that of TACCO preflight data entry in the P-3C ASW patrol aircraft. The specific tasks involve entering typical preflight data into the STORES MANAGEMENT and NAVIGATION PREFLIGHT tableaux. This requires the simulation to display these tableaux, as well as the INDEX tableau and to handle the interactive exchange of information by an operator simulating the TACCO's data entry functions.

In addition to the operational simulation, it was necessary for the program to collect pertinent data on subjects' performance of the data entry tasks. A number of possible measures of effectiveness (MOE's) were considered. Two, however, were judged most relevant : accuracy and entry speed; and the simulation program gathered necessary statistics on these metrics.

2. Simulation Description

Three tableaux from the P-3C operational software are functional in the simulation: INDEX, STORES MANAGEMENT and NAV PREFLIGHT. The INDEX tableau is displayed on a standard video terminal crt when the simulation is first called up - see appendix A. The INDEX tableau is a complete representation of that found in the actual aircraft as every tableau available to an operator in the aircraft is presented. From the INDEX, the simulation allows the operator to select either the STORES MANAGEMENT tableau or NAV PREFLIGHT tableau by entering the appropriate line number - see appendix A.

Once the desired tableau is displayed, the operator has a number of functions available to operate on the data. A next line function provides a means by which lines in the tableau may be accessed sequentially. Any individual line may be accessed using an enter line number function. A subsequent page of the STORES MANAGEMENT tableau may be displayed using the next page function. Correction

functions permit a BACKSPACE to the previously entered character - as with an ordinary typewriter - or a DELETE LINE, which allows deletion of the entire string of entered characters, permitting reentry of correct data. Alerts are presented to inform the operator that an invalid line number has been requested, that the current line has no modifiable characters in it, or that the current line is the last line of the page.

The simulation also collects data on a number of important factors used in determining the measure of effectiveness of the two input devices. The time required to enter the test data is maintained separately for the STORES MANAGEMENT and NAV PREFLIGHT tableaux. This time is measured as the sum of the periods between the time the cursor is properly positioned - ready to accept input - and the CARRIAGE RETURN is sent. The number of times that the DELETE LINE and BACKSPACE functions are used for each tableau is also counted. This is later used as an indicator of input error rate. When the simulation run, consisting of data entry for the two tableaux, is completed, the data in the tableaux, as entered by the operator, is placed in a UNIX file for subsequent evaluation of operational error rate by the UNIX utility "DIFF". Also, the entry times, and delete line/backspace counts are displayed on the screen at this time.

The system description, thus far, has been kept general, to provide an overview of its capabilities. The following few paragraphs will present the human factors aspects of the system in somewhat more detail.

The functions available to the operator are identical for both of the tableaux. When the requested tableau is initially presented, the first line with modifiable information - the prompt line - is displayed at the bottom of the screen, under the tableau (see the last page of appendix A). The blinking cursor is positioned on the next line directly below the first modifiable character of the prompt line waiting for data input. This is a slightly different - although functionally equivalent - presentation from that in the P-3C aircraft. That system places the cursor under the modifiable characters of the actual line in the tableau, thus writing over the previous data, as the cursor skips over any non-modifiable characters. In the actual system, then, there is no separate prompt or input line. This is not considered a significant departure from fidelity to the P-3C system, although during the simulation trials, subjects with previous P-3C experience did express a preference for the method used in the simulation because they felt it made spotting errors easier. During the initial design phase of the simulation development, fidelity to the actual systems' method of handling the data input was not considered as

critical as fidelity to that systems' capacity to handle formatting (spacing) of the data. Thus, the simulation handles the formatting of the data, so that it is not necessary to provide any blank spaces between the data elements on a line.

After the data is placed in the input area on the screen, it is entered into the tableau with a CARRIAGE RETURN. The lines in the tableau may be accessed sequentially by using the NEXT LINE key followed by a CARRIAGE RETURN or individually by entering the two digit line number followed by a CARRIAGE RETURN. This places the desired line into the prompt area. The NEXT PAGE function is available when the STORES IMAGE EDIT tableau is displayed. It requires activation of the NEXT PAGE key followed by a CARRIAGE RETURN. The INDEX may be redisplayed using the INDEX key followed by CARRIAGE RETURN.

There are two correction keys available. The BACKSPACE key moves the cursor to the previously entered character and allows the operator to reenter that character. BACKSPACE may be used to move the cursor back to the beginning of the input line if desired. DELETE LINE, followed by a CARRIAGE RETURN, however is a faster method. This function deletes all of the characters entered on the input line and repositions the cursor to the first modifiable character of that line. The operator may then reenter the data. This function works somewhat differently

than the DELETE LINE (CANCEL) function in the aircraft which deletes the characters entered for the line and terminates the data input function. The aircraft function then requires the operator to reenter the input mode if additional changes are desired.

3. Hardware

The simulation hardware consists entirely of equipment operated by the Naval Postgraduate School Computer Laboratory. The mainframe computers were PDP 11-50's manufactured by Digital Equipment Corporation. The terminal was a standard DM 2500 intelligent terminal manufactured by Datamedia Corporation. The model variant used consisted of separate keyboard and CRT units which permitted the CRT to be offset from the keyboard. This permitted duplicating the aircraft configuration where the CRT is offset vertically from the keyset.

4. Simulation Software

The simulation software was written by the authors entirely in the "C" programming language. The supporting data retrieval macros were written for a PWB/UNIX version of time sharing operating system - which also was written primarily in the C language. While the question of a language for the simulation program was first being considered, it became apparent that the project called for a structured language, one well suited to modularized programming techniques. Neither of the authors had an

extensive background in the general disciplines of computer science, or the specific area of developing interactive computer programs. However, they were familiar with the Pascal programming language and many characteristics of that language seemed well suited to the requirements of the simulation - particularly the record and scalar variable constructs. Pascal was later rejected because of undesirable input/output and file-handling idiosyncrasies of the available compiler. C, then, appeared as a likely candidate for the simulation program language for a number of reasons:

1. It is a structured language with Pascal-record-like constructs (structures)
2. It interfaces easily with the operating system
3. It easily supports interactive programming

In addition to the obvious goal of simulating the data input functions of the K-3C software, there were a number of other ideals to which the authors strove in developing the simulation software. From a personal viewpoint, it was strongly desired that the program be 'readable' with no 'magic numbers' (mysterious constants) or tricky code. That is to say, since neither of the authors had any previous experience in C programming, they wanted the code to be easily understood and "debuggable". This was accomplished primarily through the use of comments when the purpose of the code was not obvious, the liberal use of the

DEFINE statement to set values for constants or create macro functions, and a strict modularity which divides the program into discrete functional elements.

After performing some initial tests, it became obvious that a critical area of the simulation which had formerly not received any consideration was the problem of 'real time' processing of the screen data on an occasionally heavily loaded time sharing system. More specifically, each tableau had twenty-three lines of data to be written to the screen (twenty tableau lines plus alert line, prompt line and input line blanking - see appendix A.), and even with the terminal operating at 9600 baud, writing each character on each line every time a single line was modified, or when a NEXT LINE request was sent was introducing unrealistic delays waiting for the system to write the tableau to the screen. Direct cursor addressing, a technique which is apparently used in the aircraft system, was initially considered, but rejected as it was believed that this would make the simulation dependent on a single type of terminal, and it was desired to make the simulation as hardware-independent as possible.

The solution was to restrict, to an absolute minimum, the number of lines written each time a command or data was entered. Thus, when data is entered to modify a line, a maximum of three lines is written to the screen: the modified line, an alert if necessary (or removed if no

longer necessary), and a new prompt line. When a NEXT LINE or a specific line request is sent, a maximum of two lines is written: an alert if necessary (or removed), and a new prompt line. All other lines remain displayed, unchanged. Of course, every line of a tableau must be written when that tableau is initially displayed, or when, for the STORES MANAGEMENT tableau, a NEXT PAGE request is processed. However, this scheme permits data entry at a normal, unrestricted speed under all but the most extreme system loads.

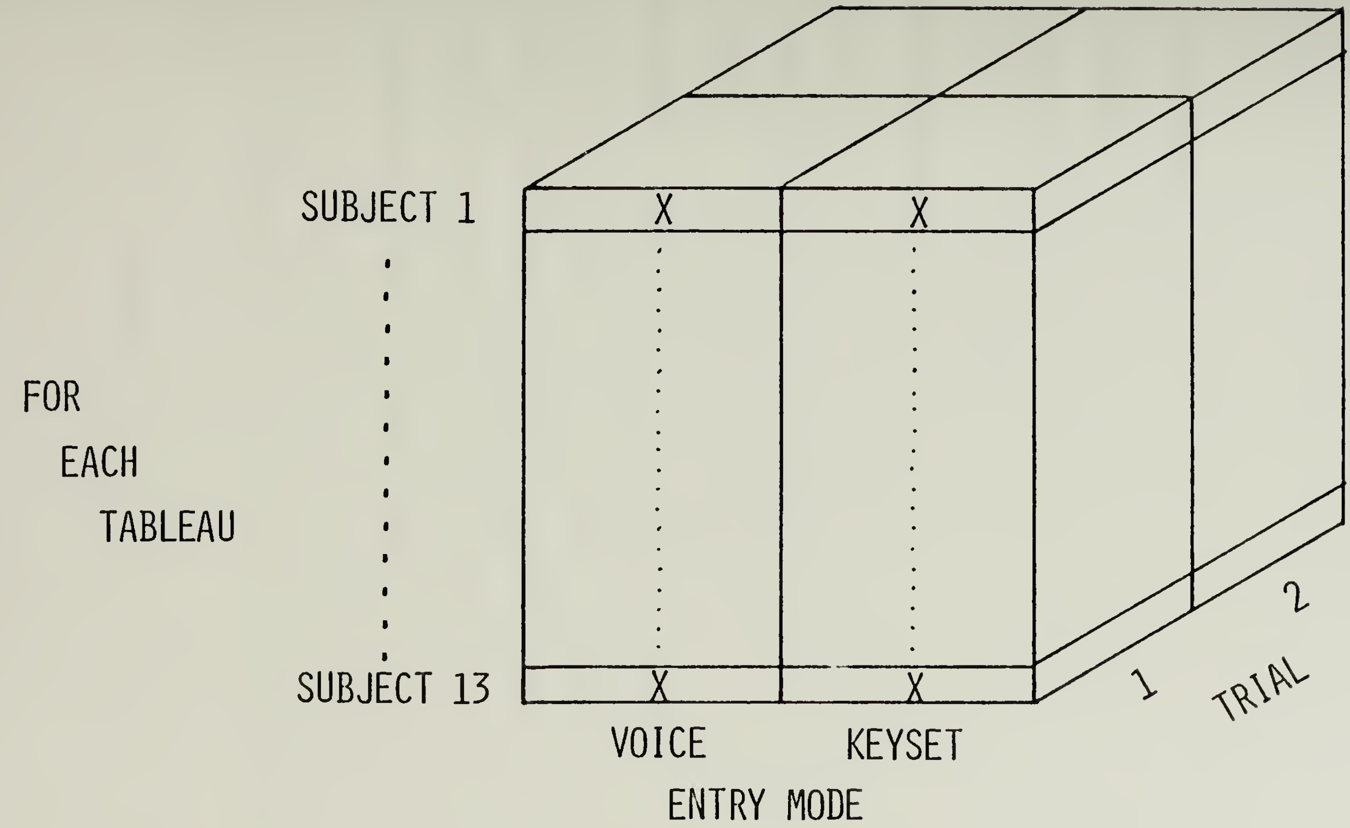
A program listing follows the appendices. For those who are more interested in a functional description of the simulation program, a pseudo-code outline of the major routines appears in Appendix D.

C. THE EXPERIMENT

The objective of the experiment was to evaluate the use of voice recognition as an input modality for preflight data in the P-3C ASW aircraft considering the MOE's of input speed and accuracy.

1. Design Considerations

Figure 1 shows the experimental design graphically, a treatment by treatment by subject approach. There were, in fact, two such experiments: one for the Stores Management tableau data entry task and one for the Navigation Preflight tableau data entry task. The experiment was designed to



CONCEPTUAL DESIGN OF THE EXPERIMENT

FIGURE 1

simulate actual software and hardware configurations of the P-3C aircraft, specifically the Tactical Coordinators position during preflight. The TACCO communicates with the computer through his matrix select switches and matrix readout switches for tactical control of his Multi Data Display, and through the TACCO keyboard for control and viewing of navigation data, Tactical stores, and Intelligence data available via the ASC. Since a tactical simulator was not available for use in the conduct of this experiment it was not feasible to evaluate the voice modality to control a tactical display and the dynamic interactions involved in so doing. The availability of the equipment in the Naval Postgraduate School Computer Laboratory allowed the design of simulation for use in inputting data into the preflight tableux of the P-3C. The Datamedia Elite 2500 CRT was used as the display device for both the keyset and voice recognition methods of entry. During the keyset entry trials the display console was physically separated from the subjects which required them to physically move their heads in order to verify a data entry. The separation of the console and the keyset equates to the separation of the TACCO's keyboard and the MDD in the P-3C.

The vocabulary for the voice input unit was restricted to 61 entries in order to minimize the time required for training and verification of the vocabulary. A

complete operational vocabulary would have 140 to 150 entries. Restricting the vocabulary to 61 entries is not considered to have affected the processing time of the system. Recall from section II that other investigators have indicated that the larger vocabulary would not be expected to cause noticeably longer processing times for the voice recognition unit [Poock, Ref. 10]. However, the effect that a larger vocabulary would have on the recognition error rate is not known.

2. Subjects

Thirteen subjects participated in the experiment on a volunteer basis with no monetary incentive. They included twelve male officers and one female officer from the Navy and Army, all of whom were students at the Naval Postgraduate School. Five were enrolled in the ASW curriculum, seven were enrolled in the Operations Analysis curriculum and one was enrolled in the Computer Science curriculum. Military experience levels ranged from Lieutenant to Lieutenant Commander in the Navy and Captain in the Army. All subjects had previous experience with some type of keyboard input to a computer system with experience level ranging from novice to proficient. Four of the subjects were either P-3C or S-3A TACCO's and had previous experience with the preflight data entry task of the experiment using the manual keyboard entry method of either the P-3C or S-3A. Only one of the subjects had ever used

voice recognition equipment. The other twelve had neither seen nor used voice recognition equipment before.

3. <u>Materials</u>

Materials used during the conduct of the experiment included:

a. A typing test which was used to determine a subjects skill level in using a standard typewriter keyboard.

b. A guide for using the voice recognition system (appendix C).

c. A simulation overview (appendix D) which described to subjects, the objective of the experiment, the simulation that was to be used , clients, entry commands and corrections, and a copy of the tableaux that were to be modified.

d. A simulation familiarization (appendix E) which was designed to give each subject time to become familiar with data entry into the simulation. The goal of this appendix was to allow subjects to read and physically enter representative data into the simulation using both voice and keyboard input modality. It also allowed subjects to practice using correction procedures for the simulation.

e. Preflight data (appendix F) which consisted of three different data sheets.

(1) Navigation Preflight data, which was used to fill in the Navigation Preflight tableau.

(2) Voice Sonobouy Status Chart, which was used to fill in the Stores Management tableau using the voice modality.

(3) Keyboard Sonobouy Status Chart, which was used to fill in the Stores Management tableau using the keyboard modality. The only difference between the voice and keyboard Sonobouy Status Charts was the use of the symbols for the depth and life settings of the sonobouys. For trials where voice was the input modality, the depths (shallow or deep) and the life settings (short or long) were spelled out. For keyboard trials the depths (S or D) and the life settings (S or L) used only

the first letter of the words. Whole words were used for the Voice Technology Status Chart to avoid confusion between shallow and short which might otherwise occur when using S for the symbol. Other than these minor differences both Status Charts contained the same data.

f. A vocabulary list (appendix G) which consisted of the 61 words used to input data to the simulation program. The vocabulary was kept at a minimum length so as to keep the amount of time spent in training the threshold 600 as low as was practicable while still maintaining optimum usage of voice technology. The vocabulary list has three columns of information. The WORD No. column is used to communicate with the T-600. The PROMPT column contains utterances that each subject trained and used when inputting data to the simulation. The third column headed OUTPUT contains characters that are sent to the Datamedia 2500 for input to the simulation program. For example word number 10 requires the subject to speak the utterance "ten long". This utterance, when recognized by the T-600 will send the output 'xxx10xxxL' ("x" defines a blank space) to the Datamedia 2500. The utterance says to send three spaces, a ten, three spaces, and the letter L which stands for "long" to the Datamedia 2500 for input to the simulation tableaux.

g. A number of forms were used to record each subjects data during the experiment (appendix H). These included:

(1) A Voice Recognition Data Sheet for each trial where time and error data were recorded.

(2) An operational error sheet that was compiled on the UNIX system which compared the data entered by each subject with a master file of tableaux contents resident in the UNIX memory.

(3) A manually kept log of T-600 recognition errors for each voice trial, and,

(4) A Voice Input Experiment Questionnaire which solicited general impressions of the voice recognition system usefulness and expectations.

4. Procedures

The experiment was run in three stages. During the first stage or meeting subjects met individually with the experimenter and were given a five minute typing test. They were then given a set of familiarization materials which described the purpose of the experiment, operation of the voice recognition system, commands necessary to use the simulation, and a copy of the System Familiarization handout which they would later use during a system familiarization run. They were then told how the voice recognition system worked and given a copy of "Using the Voice Recognition System". The experimenter showed each subject how to wear and use the headset microphone and how to effectively use the voice system. Following this basic familiarization each subject was given the vocabulary list and trained the vocabulary under the guidance and monitoring of the experimenter.

A reading of background noise level - in dBA - was taken during the training session and entered into the subjects "Voice Recognition Experiment Cover Sheet" for later reference. A background noise level reading was obtained each time subjects performed a voice entry trial.

After completing training of the vocabulary each subject spoke each of the 61 words four times. If the T-600 made a correct match for three of the four utterances it was considered that the word was properly trained for

recognition. If fewer than three out of four utterances were correctly matched then the subject retrained that particular word. This first session averaged one and one-half hours in length.

The second and third stages of the experiment required the subjects to fill in the Stores Management and Nav Preflight tableaux with data. Each subject was required to fill in the tableaux with data contained on the data sheets in Appendix F. They were required to enter the data twice for each Trial, once using voice and once using the keyboard entry method. The subjects were randomly split into two equal groups. One group performed the first run of the Trial using voice input. The other group used keyboard for the first run of the Trial. For the second trial the order was reversed. The experiment was run in this fashion to counter the effect of learning on speed and accuracy.

The subjects returned for the second stage between one and three days after completing session one. This gave them a chance to look over the familiarization material. The subjects stepped through the familiarization procedures during the first half hour of the session. During the remaining 45 minutes the subjects executed the first trial of the experiment. Each trial consisted of performing the task of entering preflight data into the Nav Preflight tableau and sonobuoy inventory into the Stores Management tableau. Both the keyset and voice modalities were used

with one half of the subjects starting with keyset entry method and the other half using voice entry method on the first Trial. Since little time was allowed for practice, the experimenter assisted the subject during the trial if the subject experienced trouble using the correction procedures. Correction technique or procedures were not considered to be key variables in the conduct of the experiment.

The third phase of the experiment again was scheduled between one to three days after the second session. During this session the subject performed the identical tasks as before but in the reverse order. After completing the trial each subject was given the Voice Input Experiment Questionnaire to fill out which solicited their general impressions about voice data entry.

5. <u>Data Analysis</u>

Data was collected, individually, for each subject by trials, tableaux, and entry method. The raw data consisted of entry times, the number of times a correction command was used, and a copy of both tableaux as completed by the subject. The times were used directly as a measure of input speed, the correction command count was used as an indicator of input or basic error rate, and the completed tableaux were examined to to determine operational errors - errors remaining after task completion.

Error rates were computed differently for the two tableaux because of the difference in the composition of their respective data. Each line of the Stores Management tableau was considered to have four potential errors since, although each consisted of six characters, the six characters represented only four bits of operational data : sonobuoy type, life, transmitter channel and hydrophone depth. This distinction was not so clear with the Navigation preflight tableau where each character was entered separately and each line contained a different type of data. Thus, for the Navigation preflight tableau, each character was considered a potential error. This concept was used in determining both operational and entry error rates.

The primary measures of effectiveness for the entry methods in this experiment were considered to be accuracy and entry speed, as indicated by operational error rate and data entry time. Thus, the emphasis in the data analysis was on these two factors as they were affected by entry method and trial number. This data was analyzed using a standard 'treatment by treatment by subject' analysis of variance technique. Additional characteristics of the data were examined using one way analysis of variance when it appeared that there might be correlations not anticipated in the experimental design. All error rates were transformed using the arcsin method before the ANOVA was performed.

VII. RESULTS

The purpose of this experiment was to determine if a voice input device would offer any speed or accuracy advantage over a conventional keyset in the performance of a specific operational task. Thus, the critical measurements were entry speed and operational error rate, ie. entry errors which were not detected by the operator and which remained after completion of the input task. Input errors were tabulated, but only as a means by which to possibly explain significant differences in data entry times. Two different tableaux were used to examine the effects of using voice input in the more advantageous situation where one utterance provides more than one bit of data output-as with the Stores Management tableau - and the less advantageous situation where one utterance gives only one bit of data output-as with the digit-by-digit entry in the Navigation Preflight tableau. Two trials were used to allow examination of the interaction of speed and accuracy with experience. The results are presented with these considerations given primary attention. However, while analyzing the data it became apparent that other interactions had taken place, and these additional results are presented where applicable. The entire raw data set for the two trials appears in tables I. and II.

TABLE [illegible]

[illegible]

SUBJ	MODE*	TIME (seconds) S*	TIME (seconds) N*	ERRORS ENTRY S	ERRORS ENTRY N	ERRORS OPERATIONAL S	ERRORS OPERATIONAL N
1	K	641	14[illegible]	[illegible]	1	0	0
	V	590	13[illegible]	0	0	1	0
2	K	696	164	[illegible]	4	[illegible]	0
	V	679	16[illegible]	13	1	[illegible]	0
3	K	51[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
	V	458	13[illegible]	[illegible]	[illegible]	[illegible]	1
4	K	457	10[illegible]	[illegible]	1	1	[illegible]
	V	539	111	[illegible]	0	1	0
5	K	61[illegible]	130	[illegible]	[illegible]	2	0
	V	436	10[illegible]	[illegible]	[illegible]	1[illegible]	0
6	K	527	105	5	0	2	0
	V	509	154	[illegible]	3	0	2
7	K	625	110	7	1	2	0
	V	787	145	15	4	1	0
8	K	951	211	1	0	0	0
	V	822	170	11	0	1	0
9	K	607	133	1	1	4	0
	V	572	135	7	0	1	0
10	K	657	145	0	0	[illegible]	[illegible]
	V	524	150	0	0	[illegible]	0
11	K	701	121	2	0	1	0
	V	612	122	10	0	1	0
12	K	712	114	5	1	0	0
	V	542	124	4	1	1	0
13	K	513	90	4	0	0	0
	V	447	81	3	0	0	0
(14)	V	437	90	1	0	0	0

* S : STORES MANAGEMENT TABLEAU V : VOICE ENTRY
N : NAV PREFLIGHT TABLEAU K : KEYSET ENTRY

TABLE II

RAW DATA TABULATION

SUBJ	MODE	TIME (seconds) S	TIME (seconds) M	ERRORS ENTRY S	ERRORS ENTRY M	ERRORS OPERATIONAL S	ERRORS OPERATIONAL M
1	K	558	173	0	0	0	0
	V	459	99	0	0	0	0
2	K	601	165	0	0	0	1
	V	630	145	15	0	4	0
3	K	419	83	4	0	5	0
	V	490	135	11	5	0	0
4	K	444	90	1	0	1	0
	V	656	215	25	0	4	1
5	K	443	112	0	1	0	0
	V	423	134	5	1	5	0
6	K	573	192	15	0	0	0
	V	553	139	17	2	0	0
7	K	547	102	10	0	0	0
	V	482	119	12	1	0	0
8	K	763	139	2	0	0	0
	V	608	175	6	0	0	0
9	K	926	117	5	0	5	0
	V	492	135	4	0	[illegible]	0
10	K	544	114	0	0	0	0
	V	441	134	[illegible]	5	0	0
11	K	685	135	15	0	4	0
	V	426	137	3	0	2	0
12	K	649	99	7	0	1	0
	V	559	154	11	0	0	0
13	K	492	75	4	0	0	0
	V	371	79	4	1	1	0
(14)	V	322	71	2	0	0	0

1. ENTRY SPEED

Table III gives a summary of the mean entry times for the two tableaux by trials, and entry method. For each tableau, there was a significant difference in entry time both between the trials and entry method. The statistical treatment is shown in tables IV and V. Figure 2 compares the entry times on trial one and two for the Stores Management tableau. The keyset was 9.1 percent faster on trial 2 and the voice was 12.6 percent faster on trial 2 ($p < 0.01$). The ANOVA indicated no significant interaction between trial and entry method. Figure 3 shows the same data for the Navigation Preflight tableau where trial 2 times were, again, faster: by 11.6 percent for keyset and by 5.4 percent for voice ($p < 0.15$). There was also a significant difference in speed between the entry methods for the two tableaux. Figure 4 shows the comparison for the Stores Management tableau, where voice entry was 4.7 percent faster than keyset entry ($p < 0.1$). Figure 5 shows this data for the Navigation preflight tableau where the keyset was 14.7 percent faster than voice entry ($p < 0.01$). The reversal of fastest entry method between the two tableaux probably reflects the character-by-character input required for voice input in the Navigation Preflight tableau and the multiple character output use of voice for the Stores Management tableau.

TABLE VIII

MEAN ENTRY TIME SUMMARY

FACTOR		STORES MANAGEMENT MEAN		NAV PREFLIGHT MEAN
TRIAL				
1		612		138
2		545		127
ENTRY METHOD				
KEYSET				
trial 1:	637		12[illegible]	
trial 2:	579		114	
		608		12[illegible]
VOICE				
trial 1:	586		14[illegible]	
trial 2:	512		140	
		549		141

TABLE [illegible]

ANOVA : STORES MANAGEMENT TABLEAU ENTRY TIMES

SOURCE	SS	df	MS	F	p*
TOTAL	765,220.92	51			
SUBJECTS	423,635.42	12			
Entry	44,080.60	1	44,080.60	4.53	< 0.10
Trial	56,760.07	1	56,760.07	9.93	< 0.01
E X T	632.01	1	632.01	0.14	N.S.
er E	116,694.31	12	9,724.53		
er T	68,582.93	12	5,715.58		
er E X T	54,456.99	12	4,538.08		

E : entry method - voice or keyset
T : trial - 1 or 2
er : error
N.S. : not significant
p* : probability of error

TABLE [illegible]

ANOVA : NAV PREFLIGHT FLTPLAN ENTRY TIMES

SOURCE	SS	df	ms	F	p*
TOTAL	55,742.95	51			
SUBJECTS	[illegible]	12			
Entry	5,671.55	1	5,671.55	8.15	< 0.01
Trial	1,742.33	1	1,742.33	3.04	< 0.15
E X T	152.25	1	152.25	0.21	N.S.
er E	8,345.64	12	695.47		
er T	6,875.92	12	572.99		
er E X T	8,568.96	12	714.08		

E : entry method - voice or keyset
T : trial - 1 or 2
er : error
N.S. : not significant
p* : probability of error

MEAN ENTRY TIMES

STORES MANAGEMENT TABLEAU

TRIAL 1 VS. TRIAL 2

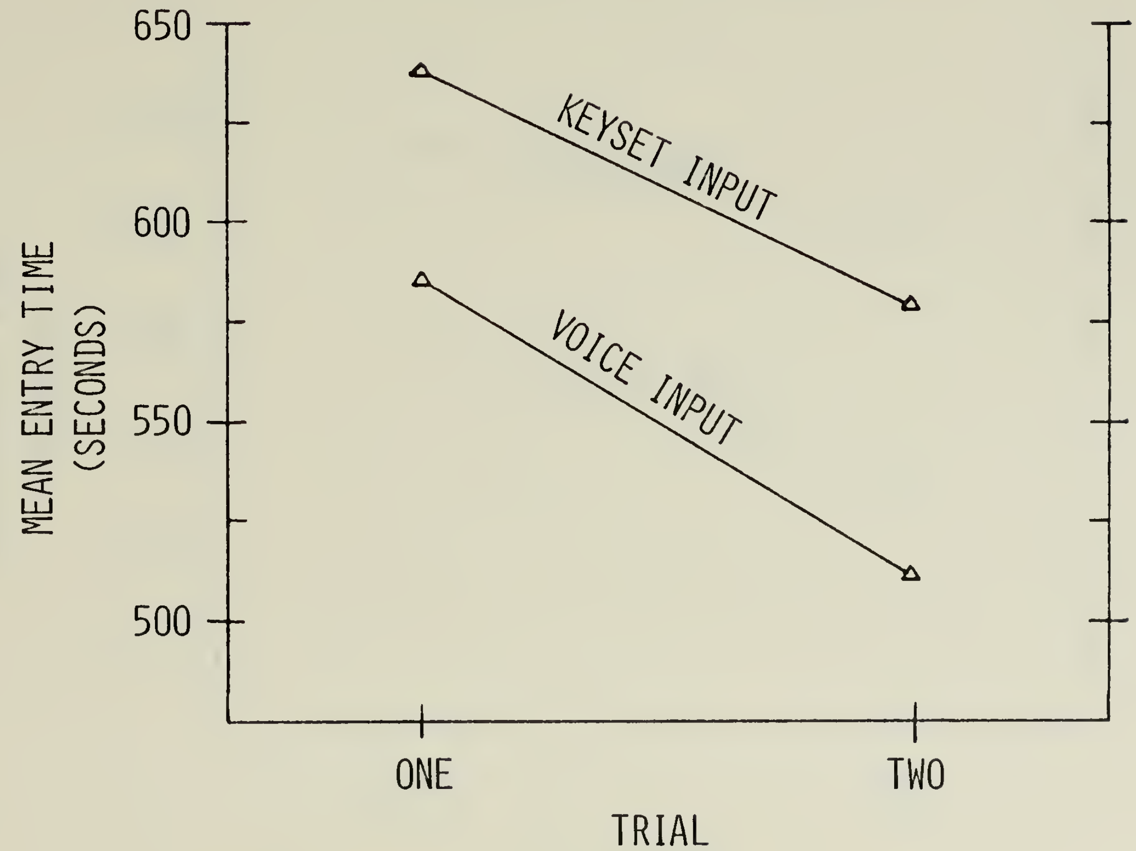


FIGURE 2

MEAN ENTRY TIMES

NAV PREFLIGHT TABLEAU

TRIAL 1 VS. TRIAL 2

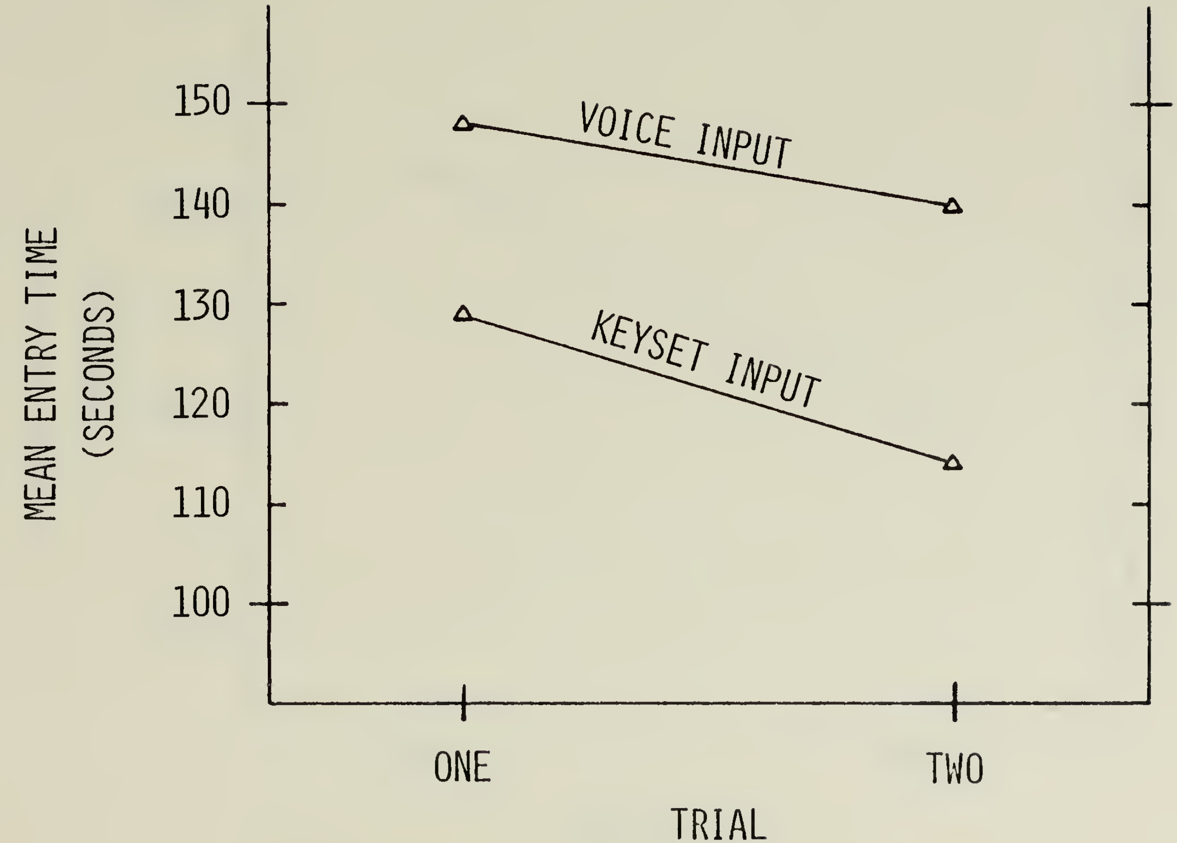


FIGURE 3

MEAN ENTRY TIMES

STORES MANAGEMENT TABLEAU

VOICE VS. KEYSET ENTRY

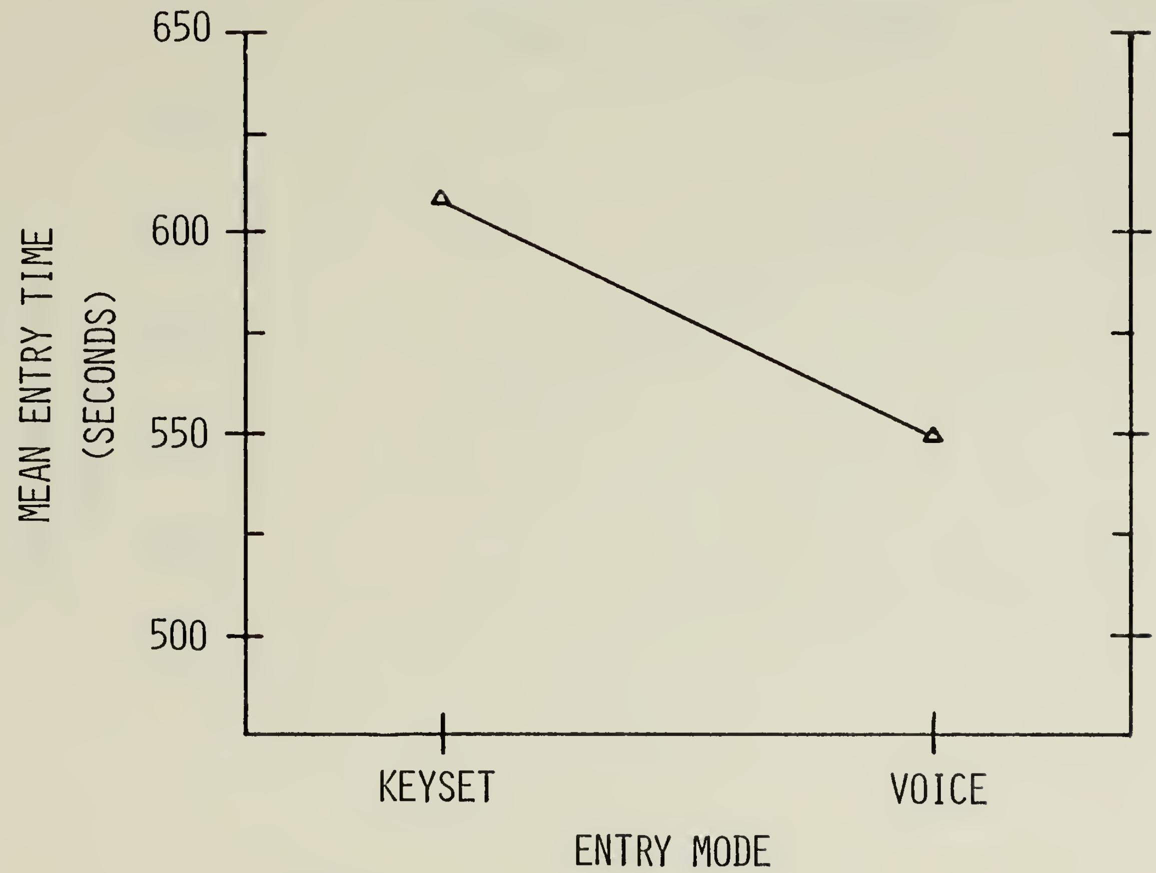


FIGURE 4

MEAN ENTRY TIMES
NAV PREFLIGHT TABLEAU
VOICE VS. KEYSET ENTRY

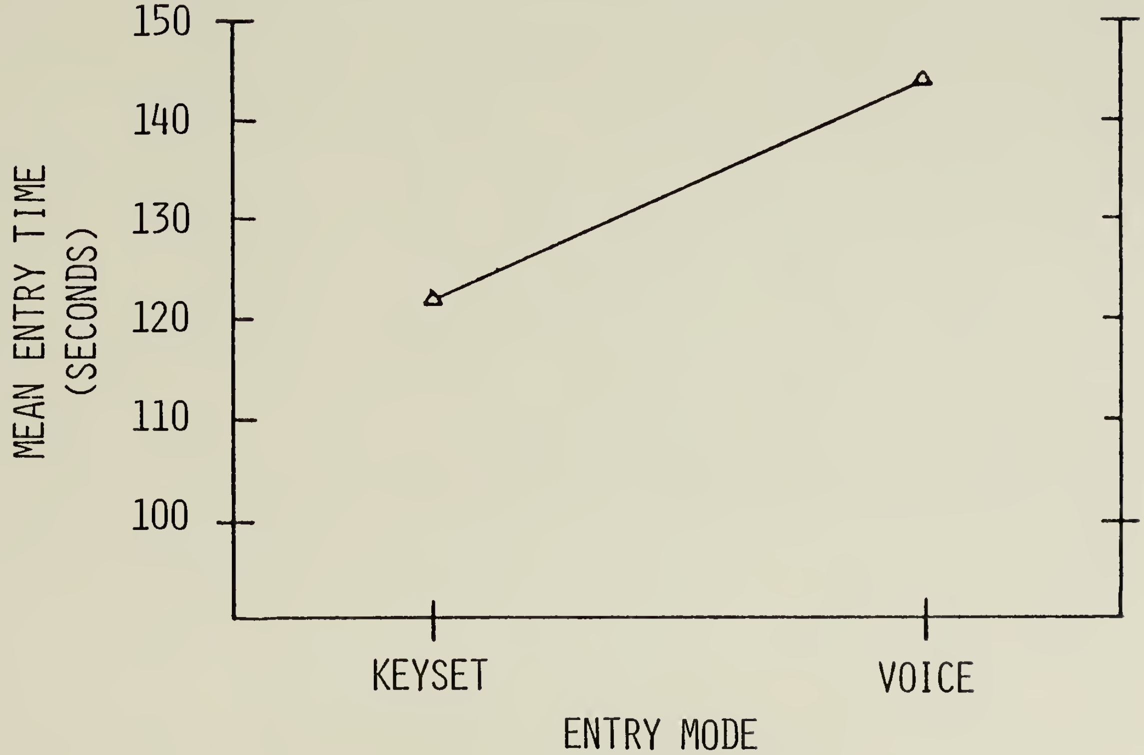


FIGURE 5

Additional analysis indicated that there was also a significant difference among the subjects for Stores Management tableau data entry times, although no such difference could be found for Navigation preflight tableau data. Since each subject had been given a typing test, ANOVA was examined for any difference between the times recorded for the fast typists (greater than 30 wpm) and the slow typists. No such difference was found. Data had also been recorded on each subjects' warfare specialty. The group contained 4 officers (subjects 1,4,5 and 13) who had previously qualified as Tactical Coordinators. This aspect was examined and a significant difference was found between the times for the TACCO group and 'others' group. The statistical results are shown in table VI. On trial two the TACCOs' mean time was 25 percent faster than the 'other' group ($p < 0.1$). There was no significant difference between the groups on trial one, possibly because everyone was still learning about the simulation at this point.

There are some additional factors to consider when evaluating the entry speed data for the keyboard. Note from the reproduction of the Stores Management tableau data in appendix F that there is a pattern in the data. That is, for a number of consecutive lines, the sonobuoy type and hydrophone depth setting remain the same (as in "41 D"), while the remaining data on the lines runs in numerical sequence such as : 10 L, 11 L, 12 L, 13 L ..17 L, etc. Some

TABLE [illegible]

ANOVA : STORED [illegible] TABLE ENTRY TIMES -
TACCO VS. OTHER BACKGROUNDS

SOURCE	SS	DF	MS	F	P
TOTAL	185955.[illegible]	12			
BACKGROUND	55958.5	1	55958.5	4.[illegible]	< 0.1
ERROR	130006.9	11	11818.8		

MEAN (seconds) : TACCO: 3[illegible] OTHER: 623

of the subjects who recorded the faster keyset entry times on this tableau did so by noting this sequence and entering a large block of data before checking the data sheet again. Since the experiment was designed to reproduce the spatial aspects of the aircraft situation, the display was moved horizontally from the keyboard the same distance as the display is situated vertically from the keyboard in the aircraft (approximately 2 feet). This normally places an additional load on the operator since he does not have the data sheet, keyboard and display in his field of view simultaneously. This 'block entry' technique thus reduced the effect of the primary disadvantage of the keyset entry: that of requiring numerous eye movements from the data sheet, to the keyboard, then to the screen and back to the data sheet to perform the entry process. Since the orderly numerical sequences do not generally occur in actual P-3 operations, this contributed to a somewhat faster mean entry speed than would be expected in normal fleet operations. To what extent this actually affected the experimental data is not known.

There is one additional factor, which might have affected the keyboard entry speed in this experiment. The aircraft keyset has a different tactile feedback than a standard keyboard such as was used in the experiment. The keyset in the aircraft requires a more deliberate, forceful key depression. The subjects who were formerly qualified

TACCOs commented on the ease of entry for the keyboard used in the experiment, compared to their recollections of the effort required for the keyset in the aircraft. Again, however, what effect this actually had on the experimental results is not known.

B. OPERATIONAL ERRORS

Operational errors - errors which remained after completion of a trial - were examined for each tableau over trials and entry method. Tables VII and VIII show the statistical treatment of the data. No significant differences could be found, indicating that, for this experiment, there was no difference in the operational error rates between the entry methods or trials.

C. ENTRY ERRORS

As was already indicated, entry error rate was not considered a primary measure of effectiveness for this experiment. Thus, an exhaustive treatment of this parameter was not undertaken. However, two aspects were found to be significant. A summary of the input errors by subject and entry method appears in Table IX. Table X shows the statistical treatment, indicating a significant difference between the mean entry error rate for the voice and keyset input device. Both rates are reasonably low - 2.4 percent for voice and 1.2 percent for keyset ($p < 0.025$). This indicates that the keyset entry error rate was half that of

TABLE XII

ANOVA : SCORES [illegible] OPERATIONAL ERRORS

SOURCE	SS	df	MS	F	p*
TOTAL	401.00	51			
SUBJECTS	142.77	12			
Entry	2.59	1	2.59	0.21	N.S.
Trial	1.54	1	1.54	0.43	N.S.
E X T	4.29	1	4.29	0.93	N.S.
er E	151.31	12	12.61		
er T	43.07	12	3.59		
er E X T	55.40	12	4.62		

E : entry method - voice or keyset
T : trial - 1 or 2
er : error
N.S. : not significant
p* : probability of error

TABLE XIII

ANOVA : NAV PREFLIGHT TABLEAU OPERATIONAL ERRORS

SOURCE	SS	df	ms	F	p*
TOTAL	402.81	55			
SUBJECTS	141.54	13			
Entry	2.24	1	2.24	1.00	N.S.
Trial	2.24	1	2.24	0.19	N.S.
E x T	0.35	1	0.35	0.05	N.S.
er E	26.92	13	2.24		
er T	148.74	13	11.44		
er E X T	86.70	13	7.22		

E : entry method - voice or keyset
T : trial - 1 or 2
er : error
N.S. : not significant
p* : probability of error

TABLE IX

BASIC ERRORS - STORES MANAGEMENT TABLEAU

	KEYSET		VOICE	
SUBJECT	NO. ERRORS	RATE(%)*	NO. ERRORS	RATE(%)*
1	0	0	0	0.0
2	5	0.8	29	4.5
3	4	0.6	14	2.2
4	1	0.2	23	3.6
5	0	0	5	0.8
6	20	3.1	25	3.9
7	17	2.7	27	4.2
8	3	0.5	17	2.7
9	6	0.9	11	1.7
10	0	0	6	0.9
11	15	2.3	13	2.0
12	10	1.6	15	2.3
13	8	1.3	7	1.1
MEAN:	6.9	1.2	15.2	2.4

RATE* = number of errors / ((number of data items) * 100)
[*** see text ***]

TABLE X

ANOVA: BASIC ERROR RATE
STORES MANAGEMENT TABLEAU
BY ENTRY METHOD

TREATMENT	SS	df	MS	F	p
ENTRY METHOD	84.65	1	84.65	8.95	< 0.025
error ENTRY	227.59	24	9.49		

the voice unit. This, of course, is a rather misleading statement when the base rate is 2.4 percent as a small shift in the absolute rate will produce a disproportionately larger shift in the relative rate.

It was observed early in the voice input device training sessions that the vocabulary was providing a real challenge to the recognition hardware. There were a number of sequences of utterances in the vocabulary which were very similar. The groups of channel number/hydrophone depths were such a sequence. There was really not much difference between "THIRTEEN LONG", "FIFTEEN LONG" and "SIXTEEN LONG", for example, or "TWENTY TWO SHORT", "TWENTY THREE SHORT" and "TWENTY ONE SHORT." Since the thrust of the experiment was to use voice entry in a natural manner, however, there were no changes to the vocabulary to accommodate this problem. The higher input error rate recorded for the voice input was likely a result of this decision. Table A7 shows all of the utterances for which an error rate greater than two percent was recorded. Note that only eight utterances - 15 percent of the vocabulary - accounted for 71.9 percent of the entry errors, and only three words - 5 percent of the vocabulary - accounted for 41.2 percent of the entry errors. A cursory examination was made of the recognition accuracy for the troublesome utterances with the numbers spoken as "TWO-TWO" instead of "TWENTY-TWO" and "ONE-SIX" vice "SIXTEEN" etc. These preliminary investigations indicated that the

TABLE XI

UTTERANCES WITH GREATER THAN 2 PERCENT RECOGNITION ERROR RATE

UTTERANCE	% OF TOTAL BASIC ERRORS	[illegible]		
22 SHORT	17.6	*	*	*
23 SHORT	12.9	*	*	*
21 SHORT	10.7	*	*	
15 LONG	9.3	*		
16 LONG	9.6	*		
17 LONG	5.9			
20 SHORT	3.3			
13 LONG	2.6			
TOTALS :	71.9 %	60.1 %	41.2 %	30.5 %

recognition error rate was indeed lower using this technique. A complete list of recognition errors recorded over the course of the entire experiment appears in Appendix I. The first section lists the utterances in the vocabulary, with all of the incorrect matches recorded for each. The second section lists each incorrect match and all of the vocabulary utterances with which each was incorrectly

As a consequence of the problem encountered with these few utterances, after the first few subjects had completed their first voice input trials, a change was made in the experimental procedure to prevent this from biasing the entry time data. If an error occurred and the subject caught the error, he was given an opportunity to delete the line and reenter the data correctly. If, on the second attempt, another recognition error occurred, and the subject realized the error occurred, he was told to pass on the incorrect data and continue. These 'recognition passes' occurred in 0.6 percent of the voice entries, although they did not occur on any trials performed by the 'experienced' voice entry users.

It is likely that entry errors affected overall voice entry speed to a greater extent than they affected the keyset entry speed, particularly with the Stores Management tableau data. Entry errors in the Navigation Preflight tableau were rather quick to correct with the 'BACKSPACE' function on either unit, since both systems used a single

input, single data output mode with that tableau. However, corrections took somewhat longer with the voice system in the Stores Management tableau. Recall that the two correction functions available were BACKSPACE and DELETE LINE. The BACKSPACE deleted the previous character and the DELETE LINE deleted the entire current line. Since the troublesome utterances were all channel number/sonobuoy life inputs, they were always the second utterance for a line. Thus, the correction option with voice was to enter six BACKSPACE commands (the voice output contained three blanks between the data items) and reenter only the incorrect output or enter a DELETE LINE command and reenter both the correct and incorrect output on the line. Since the later option was quicker - it took five to seven seconds on the average - it was the preferred method and was encouraged. Corrections on the keyset were much faster, and were generally made with the BACKSPACE key since it could be activated very rapidly. With these considerations, it seems reasonable to conclude that voice entry times would have been considerably faster if the number of recognition errors could have been reduced for those eight troublesome utterances.

It occurred to the authors that, as a group, the former TACCO's might have a lower input error rate than the 'other' group because of experience gained in talking on aircraft radios. However, when this was examined using the

Navigation preflight tableau entry error data, no significant difference could be found. Whether this was due to some of the 'other' group having similar experience, with bridge radios, for instance, or whether the premise was not valid is not known.

D. EXPERIENCE WITH VOICE INPUT

This category arose from the examination of the data after the experiment was concluded. It had not been considered in the experimental design primarily because of the difficulty in acquiring volunteer subjects with voice input experience. It had been assumed from the start that a person familiar with voice entry would be more effective than someone who had a total of only a half hour's experience with the system, as did twelve of the subjects when they started their first trial in this experiment. Both of the authors had used voice input during a previous voice entry project. One took part in the complete experiment(subject 15) and one completed only the voice entry trials. Since two data points do not make for very good statistical inference not much can be said with statistical significance about the following comparisons. However, they are presented because they do provide some insight into the capabilities of the voice input system when used by reasonably experienced personnel.

Table XII summarizes the results for both tableaux by experience with voice entry. For the Stores Management tableau, the two experienced voice entry users demonstrated a 30 percent faster mean entry time. The distribution of entry times among the 14 subjects appears in figure 6. Note that none of the inexperienced group had entry times as fast or faster than the 2 experienced users. The distribution of input error rates for the Stores Management tableau is shown in figure 7. The experienced users had a input error rate of 1.35 percent, which is approaching the overall keyset average of 1.2 percent shown in table IX.

One of the most interesting results, however, is the spectacular increase in entry speed for the Navigation Preflight tableau demonstrated by the 2 experienced voice input users. Figure 8 shows the distribution of Nav Preflight tableau entry times by experience level. Table XII, shows the mean entry time of the 2 experienced users to be 48 percent faster than that of the inexperienced group. This mean, at 304 seconds, is slightly faster that the fastest keyset time recorded for that tableau, and 50 percent faster than the mean keyset time (over both trials) of 608 seconds. This suggests that voice input may be considerably faster than keyboard input even for the least advantageous (for voice input) circumstance of character-by-character data input.

TABLE [illegible]

VOICE ENTRY TIME AND BASIC ERROR RATE -
BY EXPERIENCE LEVEL
(trials 1 and 2 combined)

CATEGORY	MEAN ENTRY TIME (SECONDS) [illegible]	[illegible]	MEAN BASIC ERROR RATE * [illegible]
12 INEXPERIENCED VOICE ENTRY USERS	551	149.1	2.48
2 EXPERIENCED VOICE ENTRY USERS	394	77.8	1.55
PERCENT CHANGE:	-30 %	-48 %	-[illegible] %

*ERROR RATE = (no. of errors /([no. of data items] * 100)
[*** see text ***]

DISTRIBUTION OF ENTRY TIMES
STORES MANAGEMENT TABLEAU
EXPERIENCE VS. INEXPERIENCE
WITH VOICE ENTRY

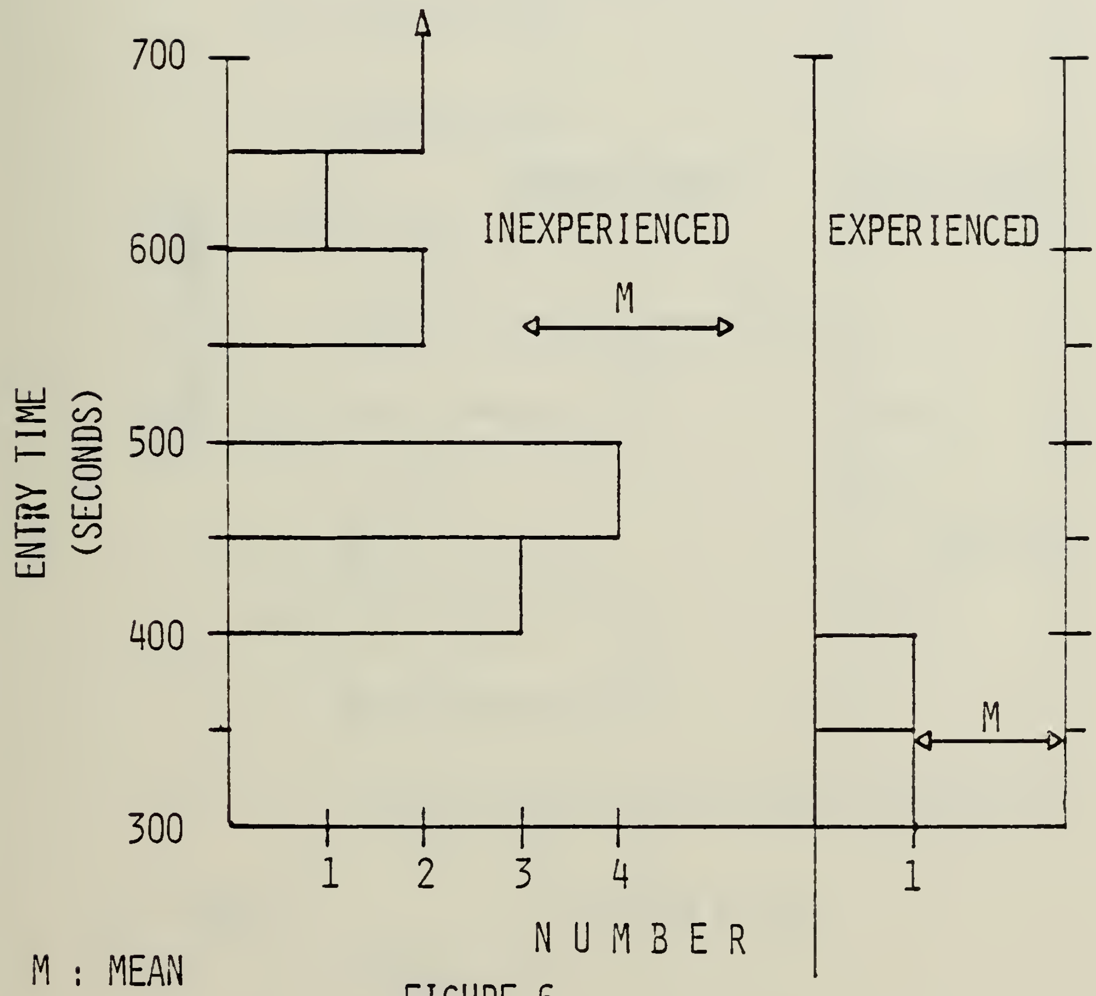
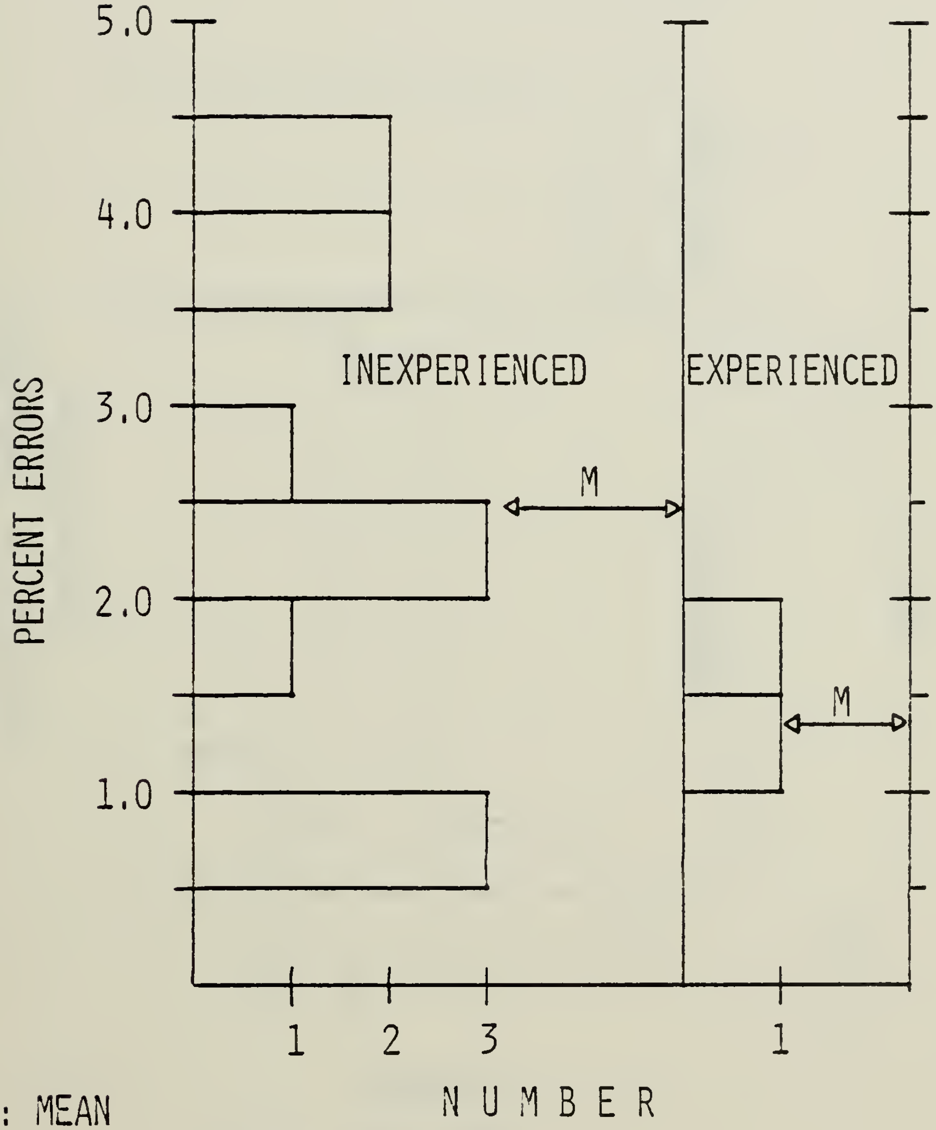


FIGURE 6

DISTRIBUTION OF BASIC ERROR RATES
STORES MANAGEMENT TABLEAU
EXPERIENCE VS. INEXPERIENCE
WITH VOICE ENTRY



M : MEAN

FIGURE 7

DISTRIBUTION OF ENTRY TIMES
NAV PREFLIGHT TABLEAU
EXPERIENCE VS. INEXPERIENCE
WITH VOICE ENTRY

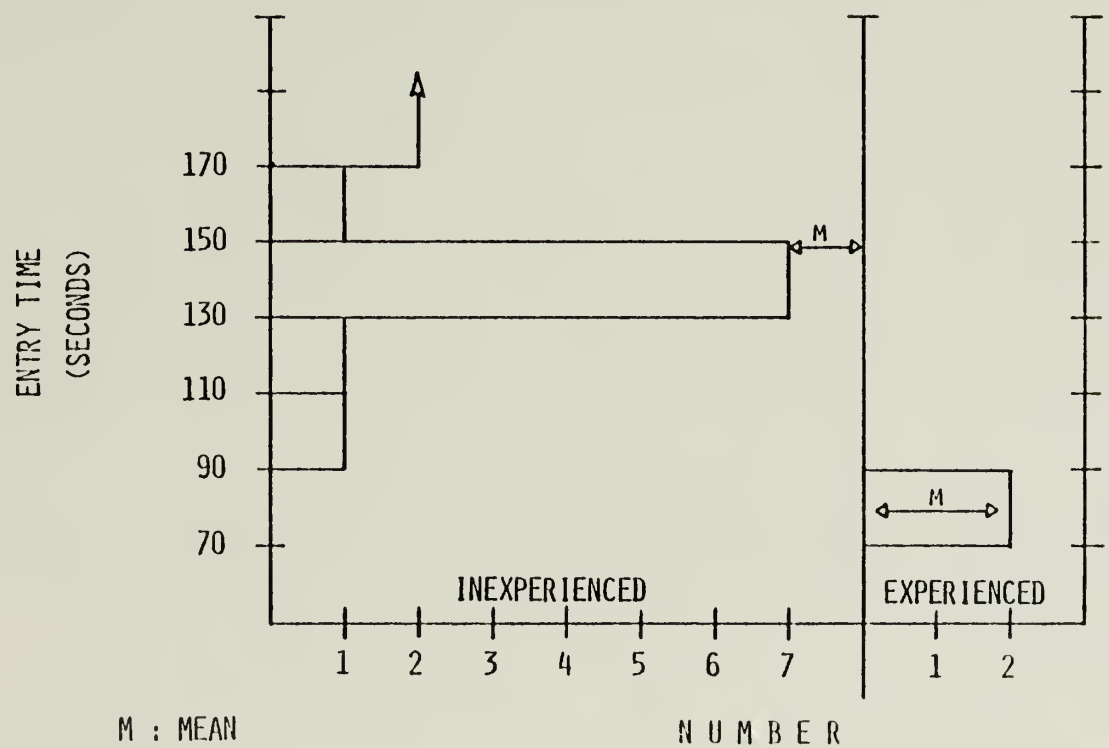


FIGURE 8

F. OTHER CONSIDERATIONS

It is interesting to note that many subjects, after comparing their voice and keyset entry times, commented that although their voice entry times were generally less than the keyset times, the actual voice entry process 'seemed' much shorter than the data indicated. Whether this was a measure of the psychological effort required on the two tasks or a measure of the novelty value of voice entry is not known.

In response to the questionnaire in Appendix D, twelve of the subjects indicated a preference for using voice input with the Stores Management tableau data input task by scoring 5 or higher on a seven point scale (seven most favorable to voice). Most believed that the primary advantage of the voice input for them was that it freed the eyes to verify the input on the display and resulted in less fatigue and less chance of committing errors. The responses were generally neutral for question 4 which asked if they thought voice input had any advantages over the keyset for the Navigation Preflight tableau input task. Eleven of the thirteen responded with a six or seven to question three which asked if they would like to use voice input in every day tasks, if it were applicable.

IV. CONCLUSIONS AND RECOMMENDATIONS

The experiment was designed to test the MOE's of entry speed and operational error rate between voice technique and keyboard technique for preflight data entry into the P-3C ASW aircraft.

A. CONCLUSIONS

The conclusions would be less than complete if mention was not again made regarding the experience levels of the test subjects. All of the subjects were familiar with and had used keyboard entry systems prior to the experiment. It must be emphasized that the subjects were very inexperienced with voice entry techniques. Even after the experiment was concluded the amount of time that test subjects had accumulated on the T-600 was one and one-half hours, which included the time spent training the vocabulary. The two experienced users were not experts in using voice systems, but as mentioned earlier had completed a previous experiment using the T-600.

When determining conclusions of the experiment, two factors must be considered. These are:

1. The type of voice data entry, which was either multiple character input for the Stores Management tableau, or character-by-character input for the Navigation Preflight tableau.

2. The experience of the users.

Based on the results from the Stores Management tableau, proficiency of the users, and subjective remarks received from the test subjects on the post-experiment questionnaire, it was concluded that voice entry of pre-flight data into the P-3C weapon system was faster and less fatiguing than keyset entry. Additionally, with increased experience using the voice system, the ease of data entry and speed of input could become more pronounced as was observed with the two experienced users of the T-600.

Based on the results of the Navigation Preflight tableau the voice mode was significantly slower than the keyboard mode. This has been borne out in previous literature with the conclusion that character-by-character input favors keyboard entry methods. However the experienced subjects, using the voice modality, were able to complete the Navigation Preflight task faster than the keyboard entry times of any of the inexperienced subjects. As a final conclusion it can be stated that even in a task which does not favor the voice mode of entry, such as with the Navigation Preflight task, an experienced user of voice systems can input data as fast or faster than standard keyboard methods, and with an input error rate that is comparable.

B. RECOMMENDATIONS

To effectively implement a voice system for a platform such as the P-3C, it is recommended that the designer:

1. Examine the task in which the voice system is to be used.

2. Determine the vocabulary that is used by the operators when engaged in the task.

3. Design the voice recognition vocabulary to equate with the natural vocabulary of operators when engaged in the task.

4. Test the vocabulary in operational scenarios to determine the set of frequently mis-recognized utterances.

5. Retrain the problem utterances.

6. If retraining does not substantially reduce the recognition errors, then modify the utterance, keeping modifications close to the jargon of the operators.

7. Determine population size of the operators for a particular task. The smaller the population size, the more tailored the vocabulary can be to the individual.

Some considerations when applying current voice systems to the P-3C:

1. The vocabulary must be trained in the background noise in which it is intended to be used. The recognition error rate of the T-600 is low as long as it is used in the same DbA level and background frequency spectrum as it was trained in. If the difference in the level of background noise is greater than about 7 DbA from that in which it was trained, the recognition error rate will show an increase [Ref. 11].
2. Crewmembers need to communicate with each other over the ICS thus causing some problems in design of a dual communications system.

3. Voice input is not the best input method for all cases, thus the requirement to maintain the current keyboard and matrices.

This experiment has shown that for a small portion of the P-3C mission that voice entry was more efficient than the standard keyboard entry currently in use. Subjectively, test subjects on the whole stated that voice entry was much less fatiguing than standard keyboard entry. The voice mode required far less eye, hand, and head movement to enter data. In fact it required only that the subjects move their eyes from the inventory list to the APU and back. It could be argued that the novelty of voice entry was responsible for the test subjects response. While this factor was not tested in the experiment, it is the authors opinion that novelty was but a minor factor. Voice entry is a natural and comfortable input medium to a computer system.

Given the length of the P-3C mission and amount of data which must be input to the system for processing it is recommended that NADC continues its work on operational scenarios for voice data input for the P-3C. Voice data input could be a significant factor in crew alertness when length of mission is considered. With the pending extended mission P-3C upgrade, its role could be considerable.

APPENDIX [illegible]

SIMULATION TABLEAUS

I N D E X

01 STORES MANAGEMENT

02 WEAPONS INVENTORY

03 SYSTEM STATUS

04 ACOUSTIC STATUS

05 NON-ACOUSTIC STATUS

06 FLIGHT PLAN

07 NAV TRACK REGISTER

08 NAV PARAMETERS

09 GEO CORRECT

10 NAV PREFLIGHT

11 PIM

12 COMMUNICATION

13 TTY RECEIVED

14 DATA LINK CONTROL

15 REMOTE TRACK

16 PLAIN TEXT RECVD

E N D

*** STORES MANAGEMENT TABLEAU ***

STORES MANAGEMENT

2	LOC	TYP	S	ST	L
3	14	041	8	18	D
4	15	041	8	19	D
5	16	041	8	20	D
6	17	041	8	21	D
7	18	041	8	22	D
8	19	041	8	23	D
9	20	041	8	24	D
10	21	041	8	25	D
11	22	041	0	10	L
12	23	041	0	11	L
13	24	041	0	12	L
14	25	041	0	13	L
15	26	041	0	14	L
16	27	041	0	15	L
17	28	041	0	16	L
18	29	041	0	17	L
19	[illegible]				

STORES MANAGEMENT

	LOC	TYP	S	SF	L
3	34	047	8	18	D
4	35	047	8	19	D
5	36	047	8	20	D
6	37	047	8	21	D
7	38	047	8	22	D
8	39	047	8	23	D
9	40	047	8	24	D
10	41	047	8	25	D
11	42	053	0	10	L
12	43	053	0	11	L
13	44	053	0	12	L
14	45	053	0	13	L
15	46	053	0	14	L
16	47	053	0	15	L
17	48	053	0	16	L
18	49	053	0	17	L
19	[illegible]				

STORES [illegible]

	LOC	TYP	[illegible]	[illegible]	L
3	54	053	8	1[illegible]	0
4	55	053	8	1[illegible]	0
5	56	053	8	2[illegible]	0
6	57	053	8	21	0
7	58	053	8	22	0
8	59	053	8	23	0
9	60	053	8	24	0
10	61	053	8	25	0
11	62	047	0	1[illegible]	0
12	63	047	0	1[illegible]	0
13	64	047	0	2[illegible]	0
14	65	047	0	21	0
15	66	047	0	22	0
16	67	047	0	23	0
17	68	047	0	24	0
18	69	047	0	25	0
19		[illegible]	[illegible]	[illegible]	

STORES [illegible]

	LOC	TYP	[illegible]	[illegible]	L
3	74	041	0	18	0
4	75	041	0	19	0
5	76	041	0	2[illegible]	0
6	77	041	0	21	0
7	78	041	0	22	0
8	79	041	0	23	0
9	80	053	0	1[illegible]	0
10	81	053	0	19	0
11	82	053	0	20	0
12	83	053	0	21	0
13	84	053	0	22	0
14	85	053	0	23	0
15	86	053	0	24	0
16	87	053	0	25	0
17	88	053	8	10	0
18	89	053	8	11	0
19		[illegible]	[illegible]	[illegible]	

```
     STORED       RANGE EST

       LOC    TYP     0     RF      L
 3      94    053     0     12      L
 4      95    053     0     13      L
 5      96    053     0     14      L
 6      97    053     0     15      L
 7      98    053     0     16      L
 8      99    053     0     17      L
 9     100    041     0     24      S
10     101    041     0     25      S
11     102    041     0     10      L
12     103    041     0     11      L
13     104    041     0     12      L
14     105    041     0     13      L
15     106    041     0     14      L
16     107    041     0     15      L
17     108    041     0     16      L
18     109    041     0     17      L
19               E N D
```

```
 N A V   P R E F L I G H T

01   TIME  :          1030    10
02   DATE  :         05  27   81
03   LAT   :       37   24   [illegible]
04   LONG  :     122   02   48[illegible]
05   OP MODE          [illegible]
06   PRIMARY  INS:  0       1
07            DOP:  1       [illegible]
08   BACK UP  INS:  0       [illegible]
09            DOP:  0       [illegible]
10             AD:  1       [illegible]
11
12   IFF CODES
13       MODE 1:    35
14       MODE 2: 6534
15       MODE 3: 5200
16
17  BUNO/SQ     : 152204   19
18  COMM ADDR  :      5274[illegible]
19  CREW/EVENT:   10     [illegible]
                                       *** ALERT   AREA ***
     *** PROMPT   LINE ***
     ***  INPUT   LINE ***
```

APPENDIX B

```
SIMULATION PROGRAM FUNCTIONAL OUTLINE


MAIN() (perform housekeeping functions)
*  create file for writing completed tableaus
*  call INITIALIZE() to initialize the page
   structures to data in "sonodata", "index"
   and "preflight" unix files.
*  call INDEX()
*  display entry times, linedelete and
   backspace counts
*  write completed tableaus to unix file
END MAIN


         PRIMARY SUPPORTING FUNCTIONS:
----------------------------------------------------

INDEX()  (display INDEX tableau and run the simulation )

*  display INDEX tableau and "LINE NO.?" prompt
*  WHILE simulation termination is not requested :
     :  call PREFLT() and SONOSTRS() as requested
        by the operator
     :  END WHILE
*  return to MAIN()
END INDEX
----------------------------------------------------

PREFLT()    ( handle  display  and  modification
             of HAV PREFLIGHT tableau)

*  call WRITEPAGE() to write tableau and prompt line
*  while  input  is  not  an  INDEX  request  do:
     :  call INPUT() to process the input
     :  execute SUMTIME macro to sum up input times
     :  call  CHECKLTIME()  to  determine  if  alert
        is required
     :  set value for input line cursor placement
     :  call WRITEPAGE() to write any changed line,
        prompt and input lines
     :  END WHILE
*  return to INDEX()
----------------------------------------------------

SONUSTRS()    ( handle  display  and  modification
                of SIORKFO ASSIGNMENT tableau  )

*  call WRITEPAGE()
```

```
*  while input is not an [illegible] request do:
    :  call INPUT()
    :  execute [illegible]
    :  call CHECKLINE()
    :  If input was next page request :
          call [illegible] for new page
       Else :
          call [illegible] for current page
   :END WHILE
--------------------------------------------------------------
```

WORK DAY C

USING THE VOICE RECOGNITION SYSTEM

* KEEP THE MICROPHONE POSITION CONSTANT, NEARLY TOUCHING THE SIDE OF THE MOUTH

* SPEAK WITH CONSISTENT VOLUME

* WHEN TRAINING THE VOCABULARY, VARY THE INFLECTIONS TO INCLUDE THE RANGE OF YOUR NORMAL PRONUNCIATIONS. DON'T INCLUDE UNUSUALLY EXACTING PRONUNCIATIONS UNLESS YOU NORMALLY SPEAK THAT WAY. THIS IS PARTICULARLY IMPORTANT WITH WORD ENDINGS.

* WHEN TRAINING THE VOCABULARY, SPEAK AT YOUR NORMAL SPEED.

* USE THE MICROPHONE SWITCH AS NECESSARY TO ELIMINATE BREATHING NOISE OR UTTERANCES NOT INTENDED TO BE PROCESSED BY THE VOICE SYSTEM.

* WHEN TRAINING THE VOCABULARY, YOU WILL BE SPEAKING EACH UTTERANCE TEN TIMES. YOU MIGHT FIND IT EASIER TO KEEP TRACK OF THE WORD COUNT BY SPEAKING IN GROUPS OF THREE UTTERANCES (3-3-3-1).

* BE CERTAIN TO LEAVE A DISTINCT PAUSE BETWEEN UTTERANCES, BOTH DURING TRAINING RUNS AND SIMULATION RUNS. THE GREEN READY LIGHT ON THE TAPE DRIVE WILL BE ILLUMINATED DURING THESE PAUSES.

APPENDIX C

SIMULATION OVERVIEW

The objective of this experiment is to evaluate the use of the ITI 600 voice recognition unit as an input device for preflight data in the P-3C ASW aircraft. You will be using a simulation of the software used in the P-3C for that purpose. Data will be entered using both a conventional keyset and the voice recognition unit. However before you can use this simulation you need to become familiar with the commands necessary to work your way through the system. That is the purpose of this document.

There are three tableaus with which you will be dealing in this experiment. A tableau is a method of displaying data to an operator, and a tableau may have more than one page. The preflight tasks which you will be performing require you to change or insert data into these tableaus. Look at the appendix now and familiarize yourself with the three tableaus. The INDEX tableau displays all of the other tableaus which are available for modification or examination in the actual aircraft. However, for the purposes of this experiment, we have implemented only two of these tableaus: STORES MANAGEMENT and NAV PREFLIGHT.

When a tableau is displayed on the screen, the screen actually consists of four parts (please refer to the last tableau in the appendix). The major part is filled with the contents of the tableau, that is, the data contained in it. The very next line after the last line of tableau data is the alert area. Various system alerts will appear here, off to the side somewhat, to indicate some condition which requires your attention. These alerts will be described more fully later.

Immediately below the alert area is the prompt line. Here is displayed the entire text of the line which is available for data input. Note that each line of the tableau begins with a line number, followed by a non-modifiable part, which is then followed by the modifiable characters. There is no need for you to know which section is modifiable as the final section of the screen handles that for you. This is the input line. This is where the system cursor will appear. The system cursor is a one-character long blinking line which is a prompt for data input. It appears one line under the first modifiable character in the prompt line. Even though the data in the

prompt line may have spaces interspersed among characters of data, it is not necessary to leave any spaces when you make your input, as the system will take care of correctly formatting the input for you. As a final note, it will always be required that if a data entry consists of a single digit 1 through 9 you must enter the data with the leading zero; ie 01 vice 1 or 05 vice 5. This is also true when entering line numbers.

The nature of the data you will be entering will depend on which of the tableaus you are modifying. The NAV PREFLIGHT(navigation preflight) tableau contains data relative to the conduct of the flight such as initial starting position, time, date, squadron, crew number and such. The SICRES MANAGEMENT(sonobuoy listing) tableau contains all of the data on the number, type, radio channel, life and hydrophone depth setting of all of the sonobuoys aboard. A sonobuoy is an expendable device dropped from the aircraft which contains a hydrophone and a radio transmitter. It transmits any sounds that it receives(hopefully from the target submarine) back to the aircraft, where a crewman attempts to determine if the sounds are those of a submarine.

SUMMARY OF KEYSET SYSTEM COMMANDS

DESIRED ACTION	REQUIRED INPUT
DISPLAY NEXT LINE FOR MODIFICATION	'RETURN' key
ENTER DATA	'RETURN' key
DISPLAY LINE n FOR MODIFICATION	'n RETURN' (n is line no. with leading zero if less than 10)
BACKSPACE (back space one character)	' ← ' key
DELETE LINE (erase entire input line)	'DELETE LINE' key then 'RETURN'
DISPLAY NEXT PAGE OF TABLEAU (STORES MANAGEMENT only)	'n' or 'N' key then 'RETURN'
DISPLAY INDEX TABLEAU	'i' or 'I' then 'RETURN'
DISPLAY STORES MANAGEMENT TABLEAU (applicable only when INDEX displayed)	'01' 'RETURN' (ie. display line 1)
DISPLAY NAV PREFLIGHT TABLEAU (applicable only when INDEX displayed)	'10' 'RETURN' (ie. display line 10)

SUMMARY OF VOICE INPUT SYSTEM COMMANDS

DESIRED ACTION	SPOKEN INPUT
DISPLAY NEXT LINE FOR VERIFICATION	"NEXT LINE" OR "ENTER"
ENTER DATA	"ENTER"
DISPLAY LINE n FOR MODIFICATION	"LINE <n>"
BACKSPACE (backspace one character)	"BACKSPACE"
DELETE LINE (erase entire input line)	"DELETE LINE"
DISPLAY NEXT PAGE OF TABLEAU (STORES MANAGEMENT only)	"NEXT PAGE"
DISPLAY INDEX TABLEAU	"INDEX"
DISPLAY STORES MANAGEMENT TABLEAU (applicable only when INDEX is displayed)	"STORES MANAGEMENT"
DISPLAY NAV PREFLIGHT TABLEAU (applicable only when INDEX is displayed)	"NAV PREFLIGHT"

SUMMARY OF SYSTEM ALERTS

ALERT	MEANING / ACTION REQUIRED
INVALID LINE NO.	REQUESTED LINE DOES NOT EXIST / TRY AGAIN
NON-MODIFYABLE LINE	CURRENT PROMPT LINE IS NOT MODIFYABLE / SELECT A MODIFYABLE LINE
END OF PAGE	CURRENT PROMPT LINE IS THE LAST LINE OF THE CURRENTLY DISPLAYED PAGE / NONE

APPENDIX E

SIMULATION FAMILIARIZATION

Prior to running the experiment you will be given time to become familiar with the data entry into the computer by communicating data information using both voice data entry procedures and keyboard entry procedures. The goal of the familiarization phase is to become familiar with the types of data to be entered and the control functions necessary for smooth data entry.

The Summary of Keyset System Commands and the Summary of Voice Commands are located at the end of the Simulation Overview section. Each command will be utilized in the familiarization excersie which follows.

VOICE DATA ENTRY FAMILIARIZATION

1. Put headset mic on.

2. Index displayed

3. Display Stores Management tableau: use command "STORES" "MANAGEMENT"; the display will then show the first page of the Stores Management tableau.

4. Advance through the 5 pages of the stores management tableau using the command "NEXT PAGE". The last line of each page says -more-, indicating another page follows. The final page displays -end- in it's last line indicating that no further pages exist. Use the command "NEXT PAGE" to return you to the first page of the tableau.

5. Return to the index tableau by using the command "INDEX". The index may be called up at any time other than when a line is in the process of being modified.

6. Display Nav Preflight tableau: With Index displayed use the command "NAV PREFLIGHT". The display will show the Nav Preflight tableau.

7. Data entry:
    a. Nav Preflight displayed

    enter time
    "2" "2" "0" "0" "0" "0" "ENTER"
    line 1 220000

line 2 ready

enter date
"0" "4" "0" "1" "8" "1" "ENTER"
line 2 04 01 81
line 3 ready

enter latitude
"3" "7" "2" "1" "0" "5" "NORTH"
line 3 37 21 05N
line 4 ready

enter longitude
"1" "2" "2" "0" "3" "2" "1" "WEST"
line 4 122 03 21W
line 5 ready: line 5 shows "non-modifiable line" cue. Go to line 13 to enter mode 1 for IFF codes.

enter mode 1
"3" "3" "5" "ENTER"
line 13 335
line 14 ready

enter mode 2
"0" "5" "4" "2" "ENTER"
line 14 0542
line 15 ready

enter mode 3
"7" "7" "7" "7" "ENTER"
line 15 7777
line 16 ready: line 16 shows "non-modifiable line" cue. Go to line 17 by using either the command
"LINE17", or "NEXT LINE"
line 17 ready

enter bureau number of a/c and squadron number
"1" "5" "9" "2" "0" "4" "1" "0" "ENTER"
line 17 159204 10
line 18 ready

enter call sign
"MIKE" "MIKE" "1" "2" "3" "ENTER"
line 18 MM123
line 19 ready

enter crew and event number
"1" "0" "MIKE" "1" "1" "MIKE"
line 19 10 M11M, also cue "end of page"

TO CORRECT AN INCORRECT ENTRY

Call up the line in which error occured and re-enter correctly. For example line 2 should have been 6534 vice 6542.

Call up line 14 using the command "LINE 14".
Enter correction
"6" "5" "3" "4" "ENTER"
line 14 6534
line 15 ready

If the error is detected prior to the "enter" command a backspace function may be used by using the command "BACKSPACE".

Example:

Line 15 is being modified. The desired code is 7777 and your input is 7767 and the command "ENTER" has not been uttered Use the command "BACKSPACE" to move back one space per utterance and then inserting the correct code 77"7" "7" "ENTER". Another method of correcting the error is to use the "DELETE LINE" function which puts you back to the first data entry point of the line being modified.

Example:

Line 15 is being modified as above and the desired code is 7777 while your input was 7767 and the command "ENTER" has not been uttered. Use the command "DELETE LINE" and you will be returned to the first modifiable space in the line. Re-enter the correct data.

b. Data entry in Stores Management tableau: With index displayed use command "STORES MANAGEMENT".

All entries into the stores inventory are accomplished by two utterances. The first utterance is the sonobuoy type and it's depth setting; e.g. "41 DEEP". This is a SSQ41 lofar bouy using a deep depth setting. The second utterance is the sonobuoy channel number and its duration (how long it will transmitt before it deactivates); e.g. "23 SHORT". This is a channel 23 with a short life setting. This second utterance also has an enter function associated with it that will display the entry momentarily in the cueing area and then enter it into the inventory while simultaneously displaying the next sequential line for modification.

Observe the format of the tableau page. The cueing and

data entry area is at the bottom of the page. The first number displayed from the left is the line number of the displayed page. The second two numbers indicate where the bouy is physically stored on the aircraft.

The sequence of data entry is as follows.

Ready for entry   3   14   XX   X   XX   X
ENTER SSQ41 deep channel 25 short life by speaking the commands "41 DEEP" "25 LONG" with a short pause between entries.

Modified line: 3   14   41   D   25   S   will appear in line 3 above and   4   15   XX   X   XX   X   now appears in the cueing area.

Enter the following bouys into the system: 41 deep 10 long, 41 shallow 11 long, 53 shallow 15 long, in locations 15, 16, and 17 respectively.

CORRECTIONS

The same correction procedures apply as before. For example: Bouy location 17 should be a 53 deep 15 long vice 53 Shallow 15 Long. Correct this by calling up line no. 6 which is where bouy location 17 is held on this page. Use the command "LINE 6": line 6 is now displayed in the cueing area and is ready for modification. Enter the correct data as before; "53 DEEP" "15 LONG"

The 'BACKSPACE' command may be used here if an error is detected on the first utterance of the line, i.e. bouy type and Depth. Since there are 3 characters in the original utterance, "BACKSPACE" would need to be uttered three times to put the cursor in the first modifiable position. The correct data could then be entered. Enter the bouys on the attached bouy status chart to become familiar with the entry and correction functions. Another method of correction is the command "DELETE LINE". 'DELETE LINE' can be used when modifying a line which has not been been entered. As before it will return the cursor to the first modifiable character of the line being modified.

KEYBOARD DATA ENTRY FAMILIARIZATION

1. Index displayed

2. Display Stores Management tableau: Stores Management is line 1 of the Index. To display any line of any displayed page the operator must enter a two digit number for that line. Procedure: with index displayed depress "0" "1"

"ENTER". Stores Management is now displayed on monitor.

3. Advance through the five pages of Stores Management by using the 'next page' key ".".

4. Return to the Index by using "I" "ENTER" (terminates current tableau entry).

5. Display Nav Preflight Tableau: Enter two digit line number for Nav Preflight, "1" "3" "ENTER"

6. Data entry

   a. Nav Preflight

   Enter time: keyset entry 220000 "ENTER"
   Entered data will remain in queing area
   until "ENTER" is depressed.

   line 1 220000
   line 2 ready

   enter date
   090181 "ENTER"
   line 2 09 01 81
   line 3 ready

   enter latitude
   372405N "ENTER"
   line 3 37 24 05N
   line 4 ready

   enter longitude
   1220324W "ENTER"
   line 4 122 03 24W
   line 5 ready

   line 5 NON MODIFIABLE go to line 13
   13 "ENTER"

   enter mode 1
   335 "ENTER"
   line 13 335
   line 14 ready

   enter mode 2
   6542 "ENTER"
   line 14 6542
   line 15 ready

   enter mode 3
   7777 "ENTER"
   line 15 7777

line 16 ready

line 16 non modifiable go to line 17
Since 17 is only one line down hit "ENTER"

enter bureau number of aircraft and squadron number
15920419 "ENTER"
line 17 159204 19
line 18 ready

enter call sign
M123M "ENTER"
line 18 M123M
line 19 ready

enter crew/event
10M11M "ENTER"
line 19 10 M11M also "END OF PAGE ONE"

CORRECTION

Call up a line in which error occured and reenter data.

Example: node 2 should have been '6534' vice '6512'
call up line 14 by hitting 14 "ENTER".
enter correct data
6534 "ENTER"
line 14 6534
line 15 ready

A back space function is also available if an error is detected prior to hitting the "ENTER" key during line modification. Each "BACKSPACE" moves the cursor one space back as with the "BACKSPACE" command in the voice mode. Procedure: "BACKSPACE" to the error; enter correct data and complete the entry for the line then "ENTER" it into the system.

b. STORES MANAGEMENT data entry

Entries into the Stores management tableau follows the same rules as the voice entry with two differences. 1) Each character requires a keyset depression; e.g. "4" "1" "D" "2" "3" "L" "ENTER" and 2) Each line must be manually entered by using the enter key vice the automatic entry of the voice mode.

Procedure:

Display the INDEX by depressing "*" "ENTER". Display Stores Management by depressing 01 "ENTER". Enter buoys in buoy locations starting with location 54. Go to next page by depressing "*" "ENTER". This page starts with location 34. Hit "*" "ENTER" again to go to page 5 of Stores Management. This page starts with buoy location 54 and you are ready to enter stores. Enter the following buoys.

location	buoy
54	53 S 10 S
55	47 R 20 S
56	47 R 25 S
57	41 R 10 L

CORRECTIONS

Corrections are made with the three methods used before depending upon when the error was discovered; i.e. either after completing an entry or during an entry and prior entering it into the inventory.

Correct location 55 to read 47 S 20 S

Procedure: location 55 is in line 4 of current page
Depress 04 "ENTER"
line 4 ready
enter 47S20S "ENTER"
line 4 47 S 20 S
line 5 ready

Enter the buoys on the attached buoy status chart to become familiar with the entry and correction functions.

[illegible]

P R E F L I G H T   D A T A

DATE.............................. 27 MAR 81

TIME.............................. 1000 00Z

EVENT............................. 4114

SQUADRON.......................... VP-19

CREW.............................. 10

CALL SIGN......................... MW123

COMM ADDRESS...................... 2575M

A/C BUREAU NUMBER................. 159204

PARKING SPACE..................... LAT   37 24 03N
LONG 122 02 48W

IFF CODES......................... MODE 1   35
MODE 2   6534
MODE 3   5200

PRELOADED BUOY STATUS CHART

CHUTE	SSQ	DEPTH	CHAN	LIFE	CHUTE	SSQ	DEPTH	CHAN	LIFE	CHUTE	SSQ	DEPTH	CHAN	LIFE
14	41	shallow	18	short	34	47	shallow	18	short	54	53	shallow	18	short
15	41	shallow	19	short	35	47	shallow	19	short	55	53	shallow	19	short
16	41	shallow	20	short	36	47	shallow	20	short	56	53	shallow	20	short
17	41	shallow	21	short	37	47	shallow	21	short	57	53	shallow	21	short
18	41	shallow	22	short	38	47	shallow	22	short	58	53	shallow	22	short
19	41	shallow	23	short	39	47	shallow	23	short	59	53	shallow	23	short
20	41	shallow	24	short	40	47	shallow	24	short	60	53	shallow	24	short
21	41	shallow	25	short	41	47	shallow	25	short	61	53	shallow	25	short
22	41	deep	10	long	42	53	deep	10	long	62	47	deep	18	short
23	41	deep	11	long	43	53	deep	11	long	63	47	deep	19	short
24	41	deep	12	long	44	53	deep	12	long	64	47	deep	20	short
25	41	deep	13	long	45	53	deep	13	long	65	47	deep	21	short
26	41	deep	14	long	46	53	deep	14	long	66	47	deep	22	short
27	41	deep	15	long	47	53	deep	15	long	67	47	deep	23	short
28	41	deep	16	long	48	53	deep	16	long	68	47	deep	24	short
29	41	deep	17	long	49	53	deep	17	long	69	47	deep	25	short

[illegible]

SONO STORAGE RACK
STATUS CHART

NO.	SSQ	DEPTH	C	L	NO.	SSQ	DEPTH	C	L
74	41	deep	18	sht	94	53	shallow	[illegible]	[illegible]
75	41	deep	19	sht	95	53	shallow	[illegible]	[illegible]
76	41	deep	20	sht	96	53	shallow	14	[illegible]
77	41	deep	21	sht	97	53	shallow	15	[illegible]
78	41	deep	22	sht	98	53	shallow	16	lng
79	41	deep	23	sht	99	53	shallow	17	[illegible]
80	53	deep	18	sht	100	41	deep	24	sht
81	53	deep	19	sht	101	41	deep	25	sht
82	53	deep	20	sht	102	41	shallow	[illegible]	lng
83	53	deep	21	sht	103	41	shallow	11	lng
84	53	deep	22	sht	104	41	shallow	12	lng
85	53	deep	23	sht	105	41	shallow	13	lng
86	53	deep	24	sht	106	41	shallow	14	lng
87	53	deep	25	sht	107	41	shallow	15	lng
88	53	shallow	10	lng	108	41	shallow	16	lng
89	53	shallow	11	lng	109	41	shallow	17	lng

PRELOADED BUOY STATUS CHART

CHUTE	SSQ	DEPTH	CHAN	LIFE	CHUTE	SSQ	DEPTH	CHAN	LIFE	CHUTE	SSQ	DEPTH	CHAN	LIFE
14	41	s	18	s	34	47	s	18	s	54	53	s	18	s
15	41	s	19	s	35	47	s	19	s	55	53	s	19	s
16	41	s	20	s	36	47	s	20	s	56	53	s	20	s
17	41	s	21	s	37	47	s	21	s	57	53	s	21	s
18	41	s	22	s	38	47	s	22	s	58	53	s	22	s
19	41	s	23	s	39	47	s	23	s	59	53	s	23	s
20	41	s	24	s	40	47	s	24	s	60	53	s	24	s
21	41	s	25	s	41	47	s	25	s	61	53	s	25	s
22	41	d	10	L	42	53	d	10	L	62	47	d	18	s
23	41	d	11	L	43	53	d	11	L	63	47	d	19	s
24	41	d	12	L	44	53	d	12	L	64	47	d	20	s
25	41	d	13	L	45	53	d	13	L	65	47	d	21	s
26	41	d	14	L	46	53	d	14	L	66	47	d	22	s
27	41	d	15	L	47	53	d	15	L	67	47	d	23	s
28	41	d	16	L	48	53	d	16	L	68	47	d	24	s
29	41	d	17	L	49	53	d	17	L	69	47	d	25	s

[illegible] -15 3000 5-75)

SONO STORAGE RACK STATUS CHART

NO.	SSQ	DEPTH	C	L	NO.	SSQ	DEPTH	C	L
74	41	d	18	s	94	53	s	[illegible]	L
75	41	d	[illegible]	s	95	53	s	[illegible]	L
76	41	[illegible]	[illegible]	s	96	53	s	[illegible]	L
77	41	d	[illegible]	s	97	53	s	15	L
78	41	d	22	s	98	53	s	16	L
79	41	d	23	s	99	53	s	17	L
80	53	d	18	s	100	41	d	24	s
81	53	d	19	s	101	41	d	25	s
82	53	d	20	s	102	41	s	10	L
83	53	d	21	s	103	41	s	11	L
84	53	d	22	s	104	41	s	12	L
85	53	d	[illegible]	s	105	41	s	13	L
86	53	d	24	s	106	41	s	14	L
87	53	d	25	s	107	41	s	15	L
88	53	s	10	L	108	41	s	16	L
89	53	s	11	L	109	41	s	17	L

APPENDIX C

VOICE RECOGNITION VOCABULARY

WORD NO.	SPOKEN	OUTPUT
0	ZERO	0
1	ONE	1
2	TWO	2
3	THREE	3
4	FOUR	4
5	FIVE	5
6	SIX	6
7	SEVEN	7
8	EIGHT	8
9	NINE	9
10	10 LONG	xxx10xxxL<cr>
11	11 LONG	xxx11xxxL<cr>
12	12 LONG	xxx12xxxL<cr>
13	13 LONG	xxx13xxxL<cr>
14	14 LONG	xxx14xxxL<cr>
15	15 LONG	xxx15xxxL<cr>
16	16 LONG	xxx16xxxL<cr>
17	17 LONG	xxx17xxxL<cr>
18	18 SHORT	xxx18xxxS<cr>
19	19 SHORT	xxx19xxxS<cr>
20	20 SHORT	xxx20xxxS<cr>
21	21 SHORT	xxx21xxxS<cr>
22	22 SHORT	xxx22xxxS<cr>
23	23 SHORT	xxx23xxxS<cr>
24	24 SHORT	xxx24xxxS<cr>
25	25 SHORT	xxx25xxxS<cr>
26	41 DEEP	41xxxD
27	41 SHALLOW	41xxxS
28	17 DEEP	17xxxD
29	17 SHALLOW	17xxxS
30	53 DEEP	53xxxD
31	53 SHALLOW	53xxxS
32	INDEX	I<cr>
33	NAV PREFLIGHT	10<cr>
34	FIRE MANAGEMENT	01<cr>
35	NORTH	N<cr>
36	WEST	W<cr>
37	BACKSPACE	CONTROL H
38	NEXT LINE	<cr>
39	ENTER	<cr>
40	NEXT PAGE	n<cr>
41	LINE 1	01<cr>

42	LINE 2	02<cr>
43	LINE 3	03<cr>
44	LINE 4	04<cr>
45	LINE 5	05<cr>
46	LINE 6	06<cr>
47	LINE 7	07<cr>
48	LINE 8	08<cr>
49	LINE 9	09<cr>
50	LINE 10	10<cr>
51	LINE 11	11<cr>
52	LINE 12	12<cr>
53	LINE 13	13<cr>
54	LINE 14	14<cr>
55	LINE 15	15<cr>
56	LINE 16	16<cr>
57	LINE 17	17<cr>
58	LINE 18	18<cr>
59	LINE 19	19<cr>
60	LINE	[illegible]
61	DELETE LINE	CONTROL V <cr>

APPENDIX B

DATA FORMS

** V O I C E R E C O G N I T I O N D A T A S H E E T **

NAME...................... NUMBER....... DATE......

RUN : V1/V2/K1/K2/ STARTING MODE: V / K FILENAME..........

****** T I M E S ******

INDEX...... STORES MANAGEMENT...... NAV PREFLIGHT......

***************** E R R O R S *****************

STORES MANAGEMENT....... NAV PREFLIGHT.......

NO. LINE DELETES.......... NO. BACKSPACES..........

CONDUCTED BY: WOLFE / TAGGART

VOICE INPUT RECOGNITION ERRORS

UTTERANCE	OUTPUT	[illegible].
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

***** VOICE INPUT EXPERIMENT QUESTIONNAIRE *****

WARFARE SPECIALTY.................................

1. In general, do you like the idea of voice data input?
VERY MUCH NEUTRAL NOT AT ALL

7 6 5 4 3 2 1

2. In general, would you like to use voice input in every day tasks yourself, if it were applicable?
VERY MUCH NEUTRAL NOT AT ALL

7 6 5 4 3 2 1

3. Do you think that voice input had an advantage over the keyset input for the Stores Management Tableau data? If so, what was it?
VERY MUCH NEUTRAL NOT AT ALL

7 6 5 4 3 2 1

....

....

4. Do you think that voice input had an advantage over the keyset for the Nav Preflight tableau data? If so, what was it?
VERY MUCH NEUTRAL NOT AT ALL

7 6 5 4 3 2 1

....

....

5. Do you think that voice input has applications in your military specialty? If so, what would they be?
VERY MUCH NEUTRAL NOT AT ALL

7 6 5 4 3 2 1

....

APPENDIX I.

RECOGNITION ERROR SUMMARY

RECOGNITION ERROR SUMMARY
-BY UTTERANCE

UTTERANCE	ERROR	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
ZERO			
ONE	[illegible]	1	0.4
TWO	*	1	0.4
THREE			
FOUR	*	1	0.4
	ONE	1	0.4
FIVE	ONE	3	1.1
SIX	*	1	0.4
SEVEN	EIGHT	1	0.4
	*	4	1.5
EIGHT	THREE	3	1.1
	SIX	2	0.7
	*	1	0.4
NINE	*	1	0.4
10 LONG			
11 LONG	12 LONG	2	0.7
	10 LONG	3	1.1
12 LONG			
13 LONG	14 LONG	1	0.4
	17 LONG	6	2.2
14 LONG	13 LONG	5	1.8

UTTERANCE	ERROR	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
15 LONG	16 LONG	23	8.4
	17 LONG	1	0.4
	18 LONG	1	0.4
16 LONG	15 LONG	25	9.2
	17 LONG	1	0.4
	18 LONG	2	0.7
17 LONG	18 LONG	2	0.7
	16 LONG	5	1.8
	15 LONG	1	0.4
18 SHORT			
19 SHORT	22 SHORT	2	0.4
20 SHORT	23 SHORT	1	0.4
	21 SHORT	2	0.7
	22 SHORT	3	1.1
	*	2	0.7
21 SHORT	24 SHORT	4	1.5
	25 SHORT	22	8.1
	*	2	0.7
22 SHORT	21 SHORT	1	0.4
	20 SHORT	3	1.1
	23 SHORT	44	16.1
	19 SHORT	4	1.5
23 SHORT	20 SHORT	3	1.1
	21 SHORT	1	0.4
	22 SHORT	31	11.4
24 SHORT	23 SHORT	1	0.4
	21 SHORT	2	0.7
	22 SHORT	1	0.4
	25 SHORT	4	1.5
	*	1	0.4
25 SHORT	24 SHORT	1	0.4
	21 SHORT	1	0.4

UTTERANCE	ERROR	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
41 DEEP	*	1	0.4
41 SHALLOW	53 SHALLOW	1	0.4
	47 SHALLOW	2	0.7
47 DEEP	41 DEEP	2	0.7
47 SHALLOW			
53 DEEP			
53 SHALLOW			
INDEX	LINE 3	1	0.4
NAV PREFLIGHT	-		
STRS MANAGEMENT			
NORTH			
WEST			
BACKSPACE	NEXT LINE	1	0.4
	NORTH	1	0.4
NEXT LINE	FIVE	1	0.4
	*	1	0.4
ENTER	SIX	1	0.4
	THREE	1	0.4
	EIGHT	1	0.4
	*	6	2.2
	INDEX	1	0.4
NEXT PAGE			
LINE 1			
LINE 2			
LINE 3			
LINE 4			
LINE 5			
LINE 6			
LINE 7			

UTTERANCE	ERROR	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
LINE 8			
LINE 9			
LINE 10			
LINE 11			
LINE 12			
LINE 13	LINE 14	1	0.3
	LINE 17	2	0.7
LINE 14	LINE 15	1	0.3
LINE 15			
LINE 16			
LINE 17			
LINE 18			
LINE 19			
MIKE	FIVE	3	1.1
	ZERO	1	0.3
	13 SHORT	1	0.3
	*	1	0.3
DELETE LINE			

[* : NO MATCH]

RECOGNITION ERROR SUMMARY
BY ERROR

ERROR	UTTERANCE	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
ZERO	STAKE	1	0.4
ONE	FOUR	1	0.4
	FIVE	1	0.4
TWO			
THREE	EIGHT	3	1.1
	ENTER	1	0.4
FOUR			
FIVE	REPEAT LINE	1	0.4
	STAKE	3	1.1
SIX	ENTER	1	0.4
	EIGHT	2	0.7
SEVEN			
EIGHT	ENTER	1	0.4
	SEVEN	1	0.4
NINE			
10 LONG	11 LONG	3	1.1
11 LONG			
12 LONG	11 LONG	2	0.7
13 LONG	14 LONG	5	1.8
	15 LONG	1	0.4
	16 LONG	2	0.7
	17 LONG	2	0.7
14 LONG	13 LONG	1	0.7
15 LONG	16 LONG	25	9.2
	17 LONG	1	0.4

ERROR	UTTERANCE	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
16 LONG	15 LONG	23	8.4
	17 LONG	13	4.8
17 LONG	13 LONG	[illegible]	2.2
	15 LONG	1	0.4
	16 LONG	1	0.4
18 SHORT	[illegible]TKE	1	0.4
19 SHORT	22 SHORT	4	1.5
20 SHORT	22 SHORT	3	1.1
	23 SHORT	3	1.1
21 SHORT	20 SHORT	2	0.7
	22 SHORT	1	0.4
	24 SHORT	2	0.7
	25 SHORT	1	0.4
22 SHORT	19 SHORT	2	0.7
	20 SHORT	3	1.1
	23 SHORT	31	11.4
	24 SHORT	1	0.4
23 SHORT	20 SHORT	1	0.4
	22 SHORT	44	16.1
	24 SHORT	1	0.4
24 SHORT	21 SHORT	4	1.5
	23 SHORT	1	0.4
	25 SHORT	1	0.4
25 SHORT	21 SHORT	22	8.1
	24 SHORT	4	1.5
41 DEEP	47 DEEP	2	0.7

41 SHALLOW
47 DEEP

ERROR	UTTERANCE	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
47 SHALLOW	41 SHALLOW	2	0.7
53 DEEP			
53 SHALLOW	41 SHALLOW	1	0.4
INDEX	ENTER	1	0.4
NAV PREFLIGHT			
STPS MANAGEMENT			
NORTH	BACKSPACE	1	0.4
WEST			
BACKSPACE			
NEXT LINE	BACKSPACE	1	0.4
ENTER			
NEXT PAGE			
LINE 1			
LINE 2			
LINE 3	INDEX	1	0.4
LINE 4			
LINE 5			
LINE 6			
LINE 7			
LINE 8			
LINE 9			
LINE 10	ONE	1	0.4
LINE 11			
LINE 12			
LINE 13			
LINE 14	LINE 15	1	0.4
LINE 15	LINE 14	1	0.4

ERROR	UTTERANCE	NUMBER OF OCCURRENCES	PERCENT OF TOTAL ERRORS
LINE 16			
LINE 17	LINE 15	1	0.4
LINE 18			
LINE 19			
MIKE			
DELETE LINE			
* (beep)	TWO	1	0.4
	FOUR	1	0.4
	SIX	1	0.4
	SEVEN	1	0.4
	EIGHT	1	0.4
	NINE	1	0.4
	20 SHORT	2	0.7
	21 SHORT	2	0.7
	24 SHORT	1	0.4
	41 DEEP	1	0.4
	NEXT LINE	1	0.4
	ENTER	6	2.2
	NINE	1	0.4

[* : NO MATCH]

SIMULATION LISTING

```
#include <stdio.h>
#define STARTTIME    time(&tvec1)
#define STOPTIME   time(&tvec2)
#define SUMTIME(a)    totaltime(a)   = totaltime(a)
                                          + (tvec2 - tvec1)
#define RESET(b,a)     b = a
#define FLUSH           getchar()
#define BLANKLINE  "                                  "
#define MANYBLANKS "                                                    "
#define PURGE    "                                                              "
#define BACKSPACE      '
#define CR              '\n
#define BLANK           ' '
#define CLEARSCREEN    ''  /* ' for DM 1520 /*
#define LINEFEED       ' '\0' /* DM 1520 */
#define HOME           ' \0'    /*  031 DM1520; 014 DM2500;  */
#define BS         '
#define LO     ''     /*  CONTROL  V  */
#define MINSTARTLN     4
#define SONG           0
#define INDEX          1
#define NAV           2
#define FALSE         0
#define TRUE          1
#define TERMCODE       111
#define NOT           !
#define NUMSONPG             5     /*  number of songpages  */
#define LENSONPG            20     /*  number of lines in a songpage  */
#define LENSONVAR           15
#define LINELN            27   /*  number of char in a sline  */
#define LENINDVAR       10
#define BEGINSONGPAGE        5     /*  first songline with variable info */
#define BEGINNAVPG         1
struct spage {
        char  sline[ LENSONPG ][ LINELN ];
        } songpage[NUMSONPG],indexpg,navorpg,*pageptr;

int   page,line,term,newpage,mod,errfile,over,varlength,indent,file;
int  tmscount[4] = {0,0,0,0}:
long  totaltime[4] = {0,0,0,0};
long  tvec1,tvec2,tvec0,runtime;
int  tlocount[4] = {0,0,0,0};
int  lstimetno,linenolder,tableau;
```

```
char   *errmsg,*name,nom[20];
FILE   *fopen(),*fp1,*fp2,*fp3,*fp4;

main(){

        int   i,k;

        i = 0;
        time(tvec0);
        name = nom;
        printf("ENTER:  NAME.TRIAL NUMBER\n");
        while((*name++ = getchar()) != CR);
        *(--name) = ' ';
        name = nom;
        if((file = creat(name,0660)) < 0) {
                printf(" CANNOT CREATE %s",name);
                exit(1);
                }
        initialize();
        index();
        STOPTIME;
        runtime = (tvend - tvec0);
        putchar(CLEARSCREEN);
        printf("INDEX: OS = %d      LD = %d\n",toscount[INDEX],tldcount[INDEX]);
        printf("SOMO : OS = %d      LD = %d\n",toscount[SOMO],tldcount[SOMO]);
        printf("NAV  : OS = %d      LD = %d\n",toscount[NAV],tldcount[NAV]);
        printf(" INDEX TIME : = %d   seconds\n",totaltime[INDEX]);
        printf(" SOMO  TIME : = %d   seconds\n",totaltime[SOMO]);
        printf(" NAV   TIME : = %d   seconds\n",totaltime[NAV]);
        printf(" WALL CLOCK TIME : %d    seconds\n",runtime);
        name = nom;
        fp4 = fopen(name,"w");
        for(k = 0;k < NUMSOMOPG;k++)
                for(i = 0;i < 20;i++)
                        fputs(somopage[k].sline[i],fp4);
        for(i = 0;i < 20;i++)
                fputs(navpage.sline[i],fp4);
        fclose(fp4);
}  /* main  */

somostrs(){  /* handle display and modification of STORES MANAGEMENT tableau */

        tableau = SOMO;
        page = term = 0;
        line = BEGINSOMOPAGE;
        errfile = SOMO;
        mod = FALSE;
        errmsg = "   ";
        lsttimetoo = FALSE;

        indent = 10;  /*   LINELN - 2 - LENSOMOVAR   */
```

```
        putchar(CLEARSCREEN);
        writepage(LENSUMPG,&sonopage[page],LENSUMVAR);
        while (!term)
        {

        input(&sonopage[page].sline[line][indent]);
        SUMLINE(SUMU);
        checkline();
        if(newpage)   {
                writepage(LENSUMPG,&sonopage[page],LENSUMVAR);
                newpage = FALSE;
                }
        else
                skippage(LENSUMPG,&sonopage[page],LENSUMVAR);
        }  /* while... */
}  /* sonostrs */

input(s)    /*  process terminal input commands */
        char *s;   {
        char *p,*t,*getinput();
        int  nchar,x;

        lineholder = line;
        p = t = PURGE;
        if((p = getinput(p,0,0)) == ' ')
                return;
        nchar = (p - t); /* nchar = number of char in input; not incl CR */
        RESET(p,t);
        switch (nchar)
                {
                case 0: /* input was CR */
                        line++;
                        break;
                case 1:
                        switch (*t)
                                {
                                case 'i':case 'I': /* INDEX request */
                                        term = 1;
                                        break;
                                case 'n':case 'N': /* next page request */
                                        page ++;
                                        line = BEGINSUMPAGE;
                                        if(page >= NUMSUMPG)
                                                page = 0;
                                        newpage = TRUE;
                                        break;
                                default:
                                        break;
                                }  /* switch(*t) */
                        break;
                case 2: /* input intended to be line number */
```

```
                        if(( k = atoi(p)) > 0 ) /* then p is valid integer */
                                line = k;
                        else
                                errmsg = "INVALID LINE NUMBER";
                        break;
                default:
                        if(tableau == NAV)  /* prevent non-modifyable
                                                lines from being modified */
                                switch(line) {
                                        case 0:case 5:case 11:case 12:case 16:
                                                return;
                                        default:
                                                break;
                                        }
                        modline(p,s);
                        break;
                }/* switch(nchar)*/
        return;
}

skimpage(l,ptr,backset)  /* if line was modified,this writes it;
                                else just writes prompt line  */
        int l;
        struct  spage  *ptr;
        int  backset;  {
        int i;
        rawmode();
        putchar(HOME);
        cookedmode();
        for(i = 0;i< line;i++)
                putchar(CR);
        if(mod)
                printf("%s",ptr -> sline[line]);
        else
                putchar(CR);
        for(i = line;i < LENSUMPG -1 ;i++)
                putchar(CR);
        if(mod) {
                line++;
                checkline();
                writerror();
                if(tableau == NAV)  {
                        /*  set values for indent and varlength:  */
                        switch(line) {
                                case 6:case 7:case 8:case 9:case 10:case 19:
                                        varlength = 7;
                                        indent = 18;
                                        break;
                                case 1:case 13:case 14:
                                        varlength = 9;
                                        indent = 16;
```

```
                                        break;
                                case 2:case 14:case 15:case 17:
                                        varlength = 10;
                                        indent = 15;
                                        break;
                                case 3:
                                        varlength = 11;
                                        indent = 14;
                                        break;
                                case 4:
                                        varlength = 12;
                                        indent = 13;
                                        break;
                                case 0:case5:case 11:case 12:case 16:
                                        varlength = 25;
                                        indent = 2;
                                        break;
                                default:
                                        break;
                                }  /*  switch(line)  */
                        backset = varlength;
                        }  /*  if(tableau == NAV)  */
                mod = FALSE;
                }
                else
                        writerror();
        printf("%s",ptr -> sline[line]);
        setcursor(backset);
}

writepage(l,ptr,backset) /* write entire page + prompt + position cursor */
/* l== no. lines per page; ptr == page structure; backset== length of variable
        part of line */
        int l;
        struct  spage  *ptr;
        int  backset;  {
        int i;
        rawmode();
        putchar(HOME);
        cookedmode();
        for (i = 0;i < LENSUMPG ;i++)
                printf("%s",ptr ->sline[i]);
    /* print the modifyable line after the tableau: */
        writerror();
        printf("%s",ptr ->sline[line]);
    /*  skip to 'variable' part of line :  */
        setcursor(backset);
}
```

```
modline(ibuf,sbuf)  /* enter modified line into spage structure */
        char *ibuf,*sbuf; {
        int i;

        mod = TRUE;
        for(i = 0;i < 80;i++)  {
                while(*sbuf == BLANK )
                        sbuf++;
                if(*sbuf == CR)
                        return;
                while(*ibuf == BLANK )
                        ibuf++;
                if(*ibuf == CR)
                        return;
                *sbuf++ = *ibuf++;
        }/* for... */
        return;  /* to input()  */
} /* modline */


char  *getinput(p,bscount,charcount)  /* process input if it was not a next
                                           line, next page, or line no. request */
        char  *p;
        int  bscount,charcount;  {
        char  *s;

        RESET(s,p);
        STARTIME;
        while((*p = getchar()) != CR)  {
                switch(*p) {
                        case BS:
                                bscount++;
                                if(bscount <= charcount ) /* keep BS from
                                                             spacing prior to
                                                             beginning of struct */
                                        p--;
                                else
                                        charcount = bscount = 0;
                                tbscount[errfile]++;
                                break;
                        case LN:
                                STOPTIME;
                                FLUSH;  /* flushes out CR */
                                tldcount[errfile]++;
                                /* line = "INSTARTLN; */
                                return(0);
                        default:
                                p++;
                                charcount++;
                                break;
                        } /* switch(*p)  */
```

```
	} /* while */
	STOPTIME;
	return(p);  /*  to input  */

}  /* getinput */


checkline()  {  /*  determine if alert is required for requested line */

	switch(tableau) {
		case SUBP :
			switch (line) {
				case 0:case 1:case 2:
					line = BEGINSUBPAGE;
					break;
				case 18:case 19:
					line =18;
					errmsg = "END OF PAGE";
					break;
				default:
					if (line >= LENSUBPG)  {
						line = lineholder;
						errmsg = "INVALID LINE NO.";
					}
					break;
				}  /* switch(line)  */
			break;
		case NAV:
			switch (line) {
				/*
				case 4:case 10:case 15:
					if(mod) {
						errmsg = "NON-MODIFIABLE LINE";
						break; }
					break;  */
				case 0:case 5:case 11:case 12:case 16:
						errmsg = "NON-MODIFIABLE LINE";
						break;

				case 19:case 20:
					errmsg = "END OF PAGE";
					line = 19;
					break;
				default:
					if(line >20)  {
						line = lineholder;
						errmsg = "INVALID LINE NO.";
						}
					break;
				}  /*  switch(line)  */
			break;
```

```
		case INDEX:
			switch (line){
				case 0:
					line = 1;
					break;
				case 17:case 18:case 19:
					line = 16;
					break;
				default:
					if(line > 19)
						line = 17;
					break;
				}  /*  switch(line)  */
			break;
		default:
			break;
		}  /*  switch(tableau)  */
} /* checkline */

writerror()  {  /* write alert if required, clear it if it is no longer
		       required, or skip the line if neither of these */

	switch(*errmsg) {
		case BLANK:
			if(lstimeton)
				putchar(CR);
			else
				printf("%s%s",BLANKLINE,PURGE);
			lstimeton = TRUE;
			break;
		default:
			printf("%s****%s****      ",BLANKLINE,errmsg);
			lstimeton = FALSE;
		} /* switch */
	errmsg = "  ";
}  /* writerror */


initialize(){  /*  initialize space structures to data stored in SONODATA,
		      INDEX and PREFLIGHT files  */
	int  p,l;
	printf(" INITIALIZING FILES... ");
	fp1 = fopen("sonodata","r");
	fp2 = fopen("index", "r");
	fp3 = fopen("preflight", "r");
	for(p = 0;p < NUMSONPG;p++)
		for(l = 0;l < LENSONPG; l++)
			fgets(sonopage[p].sline[l],LINELN ,fp1);
	for(l = 0;l< LENSONPG;l++){
		fgets(indexpg.sline[l],LINELN,fp2);
		fgets(navprfpg.sline[l],LINELN,fp3);
```

```
                }

        fclose(fp1);
        fclose(fp2);
        fclose(fp3);
}  /*  initialize  */



cookedmode() {  /* return system to buffered input mode */
        int mode[3];
        gtty(1,mode);
        mode[2] &= 0177737; /* mask out raw bit */
        stty(1,mode);
}

rawmode() {  /* set system to raw input mode */
        int  mode[3];
        gtty(1,mode);
        mode[2]  |= 040;  /* Or in raw mode bit  */
        stty(1,mode);
}

setcursor(varlength) /* set cursor to position under first modifyable
                        character of prompt line */
        int  varlength;  {
        int i,k;
        printf("%s",MANYBLANKS);
        for(i = 0;i < varlength +10  ;i++)    /* MANYBLANKS has 10 more spaces */
                outchar(BACKSPACE);
}


index(){  /*  display INDEX and allow display of SONO and NAV tableaus */
        int  k;
        char *p,*t,*getinput();

        tableau = INDEX;
        while(NOT over){

                errfile = INDEX;
                line = 18;
                p = t = PURGE;
                outchar(CLEARSCREEN);
                errmsg = "??LINE NO. ??";
                writepage(LENSONPG,sindexon,25);
                if ((p = getinput(p,0,0)) == ' ')
                        continue;
                SUMTIME(INDEX);
                RESET(p,t);
```

```
                if((k = atoi(p)) > 0)  /* input is valid line*/
                        switch (k) {
                                case 1:
                                        sonostrs();
                                        break;
                                case 10:
                                        preflt();
                                        break;
                                case TERMCODE:  /*  terminates trial   */
                                        over = TRUE;
                                        break;
                                default :
                                        break;
                                }  /* switch(k) */
        }  /* while(NOT over) */
        printf(" TERMINATE TRIAL");
} /* index() */


preflt(){  /*  handle display and modification of NAV PREFLIGHT tableau */

        tableau = NAV;
        term = 0;
        line = BEGINAVPG;
        errfile = NAV;
        mod = FALSE;
        lstimetoo = FALSE;
        errmsg = "  ";
        indent = 16;
        putchar(CLEARSCREEN);
        writepage(LENGNAVPG,&navprfpg,9); /* 9 = len of line variable  */
        while(NOT term)  {
                input(&navprfpg.sline[line][indent]);
                SUMITUP(NAV);
                checkline();
                /*  set values for indent and varlength:  */
                switch(line) {
                        case 5:case 7:case 8:case 9:case 10:case 18:
                                varlength = 7;
                                indent = 19;
                                break;
                        case 1:case 13:case 19:
                                varlength = 9;
                                indent = 16;
                                break;
                        case 2:case 14:case 15:case 17:
                                varlength = 10;
                                indent = 15;
                                break;
                        case 3:
                                varlength = 11;
```

```
                                indent = 14;
                                break;
                        case 4:
                                varlength = 12;
                                indent = 13;
                                break;
                        case 6:case 8:case 11:case 12:case 16:
                                varlength = 25;
                                indent = 2;
                                break;
                        default:
                                break;
                        }  /*  switch(line)  */
        skippage(LENSUMPG,&navorion,varlength);
        }  /*  while not term  */
}  /* prefix  */
```

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Thesis
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c.1 Voice recognition as an input modality for the TACCO preflight data insertion task in the P-3C aircraft.